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JOURNAL OF
THE LEPIDOPTERISTS' SOCIETY

Volume 24 1970 Number 1

NEW RECORDS FOR NEW JERSEY WITH NOTES OF OTHER SCARCE CAPTURES IN 1967

JOSEPH MULLER
R.D. #1, Lebanon, New Jersey

Extensive aerial spraying against gypsy moths and mosquitoes, as well as air pollution may have been instrumental in an apparent sharp decline of Lepidoptera and most other orders of insects in New Jersey during 1968. Hundreds of blooming milkweed (*Asclepias*) did not attract a single butterfly in Cape May. Just as poor was blacklight and bait collecting in different localities in the State. Many larvae, not accepting their favorite food, died. This, my poorest collecting season in 25 years, induced me to write this paper.

In 1967, fourteen species not previously taken by the author in New Jersey were collected; these included seven species new for the State. Following is an annotated list of the most interesting captures.

SATYRIDAE

Euptychia mitchellii (French). A series was collected near Newton, July 13–19. These dates are a few days later than in previous years. Though similar habitats have been investigated in northern New Jersey, no other colony has been discovered.

Lethe eurydice eurydice (Johanson). A few years ago F. Rutkowski discovered this species in a wet meadow near Newton. This season a series was collected by Rutkowski and the author, July 13–19. Individuals from this population are pale, with eyespots small and the postmedian band on the underside serrate and irregular. About a mile from this meadow is a wooded swamp where the darker subspecies, *L. e. appalachia* Chermock, flies. This subspecies has darker upper- and undersides, larger eyespots, and a rounded instead of serrate and irregular postmedian band on the underside. Each subspecies seems to be limited

to its own slightly different habitat. The latter subspecies has not previously been reported from the State.
Cercyonis pegala alope, form "maritima" (Edwards). Lakehurst, July 4.

LYCAENIDAE

Euristrymon ontario ontario (Edwards). To my knowledge not more than six *E. ontario* had been collected in New Jersey before 1967. After the discovery of a new area at Lakehurst with dogbane (*Apocynum*) in bloom, 17 specimens were caught on July 1 and 4 by several collectors. Most of the hairstreaks were netted on dogbane, although milkweed (*Asclepias*) was plentiful. This area is surrounded by several species of oak (*Quercus*), wild cherry (*Prunus*), and crab apple (*Crataegus*). In the hope of obtaining eggs, five females of *ontario* were kept alive for several weeks, with dogbane flowers and sugarwater provided for food. Although the butterflies were confined with oak, wild cherry, and crab apple, all died without ovipositing.

Satyrium calanus falacer, ab. "heathii" (Fletcher). In the same meadow where *Thymelicus lineola* form "pallida" and *Euristrymon ontario* were found, one individual of *S. c. falacer*, ab. "heathii" was collected by F. Rutkowski on July 1. This specimen shows a bluish border on the underside of both fore and hindwings. This form has not been reported from New Jersey previously.

Satyrium liparops strigosus (Harris). Three individuals with orange-brown patches on the upperside of the forewings were collected at Lakehurst on July 4 by F. Rutkowski and the author. These were netted along the railroad tracks where only a few plants of dogbane were growing. The blossoms attracted mostly *S. l. strigosus*, while other hairstreaks were scarce.

Lycaena phlaeas americana, ab. "fasciata" Strecker. In a large meadow near Cassville, F. Rutkowski and the author found this species very numerous. One aberrant individual, with elongated spots, was discovered among several hundred which were examined.

HESPERIIDAE

Thymelicus lineola, form "pallida" Tutt. Although this introduced species is widely distributed throughout New Jersey, the pale form "pallida" was not recorded here before J. B. Ziegler and the author caught eight specimens at Lakehurst on July 1. Four more specimens were taken at the same locality on July 4, and more were seen.

Noctuidae

Acronicta rubricoma Guenée. Black light; Lakehurst, June 4.

Acronicta dactylina Grote, melanic form. Black light; Lebanon, June 27. A new record for the State.

Eurois occulta Linnaeus. Black light; Montague, August 27.

Oncocnemis saundersiana Grote. Black light; Lebanon, October 28.

Agrotis buchholzi Barnes & Benjamin. Black light, Lakehurst, June 4.

Eupsilia morrisoni Grote. Black light; Lebanon, November 18 and 23.

Neperigea costa Barnes & Benjamin. Black light; Montague, July 27. A new record for the State.

Magusa orbifera, "divaricata" Grote. Black light, Lebanon, August 21.

Amolita roseola Smith. Black light; Montague, July 30. A new record for the State.

Abrostola urentis Guenée. Black light; Montague, October 10.

Catocala maestosa Hulst. Bait trap; Lebanon, August 28. A new record for the State.

Zale phaeocapna Franclemont. Black light; Lebanon, April 27. Determined by genitalic dissection. A new record for the State.

Zale metatoides McDunnough. Black light; Montague, June 10. A new record for the State.

Gabara pulverosalis Walker. Black light; Lakehurst August 14. A new record for the State.

Rivula propinqalis Guenée. Black light; Lebanon, October 28.

I wish to thank C. F. dos Passos and A. E. Brower for determining some of the specimens.

A NEW SUBSPECIES OF BREPHIDIUM EXILIS FROM YUCATAN (LEPIDOPTERA: LYCAENIDAE)

Harry K. Clench
Carnegie Museum, Pittsburgh, Pennsylvania 15213

Some years ago Eduardo C. Welling, of Mérida, Yucatán, México, sent me a few specimens of a *Brephidium* he had taken on the north coast of Yucatán. It was obvious, as soon as they had been examined genitalically, that they represented *exilis* Boisduval, but they belonged to

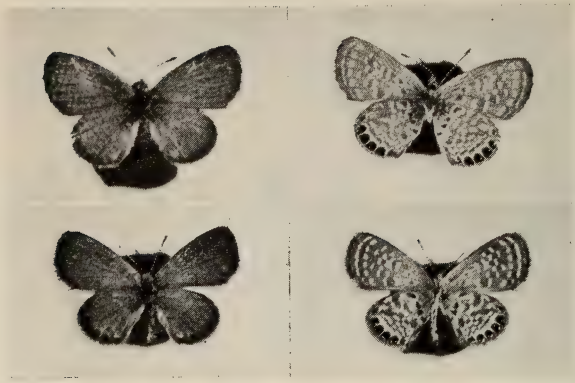


Fig. 1. *Brephidium exilis yucateca* Clench. Top left, male holotype, upperside; top right, same specimen, underside. Bottom left, female paratype, Progreso, Yucatan, 15.x.1958, upperside; bottom right, same specimen, underside.

no known subspecies. Publication was deferred, partly in the hope of obtaining additional material, and partly because more information was desirable on the distribution of *exilis*, particularly along the eastern coast of México. Both of these desiderata have now been filled.

Brephidium exilis yucateca Clench, new subspecies

This new subspecies differs strikingly from both nominate *exilis* Boisduval and subspecies *isophthalma* Herrich-Schäffer. It is about the size of *B. e. exilis* and therefore slightly larger than *B. e. isophthalma*. Above as dark as *isophthalma* and darker than, and without golden sheen of nominate *exilis*.

Hindwing often with row of faint pale (ashen) lunules capping subterminal black spots. Underside of forewing with two sharp and distinct, parallel rows of pale subterminal bars, heavier than pm series (in both *e. exilis* and *isophthalma* these usually are fainter than pm series), basal area with two sharp and clear, pale post-basal ring-like marks, one in cell and one in base of Cu_2-2A below cell, (nearly always absent in nominate *exilis;* in *isophthalma* sometimes absent and sometimes present, yet faint, the variability depending, at least to some extent, on the island source). Pm series of forewing below sharper, more distinct, with component bars slightly thicker than in either of other two subspecies; pm area of forewing underside without orange, ground color and dark hindwing discal markings chocolate brown, often grayish, very nearly concolorous with the forewing base (in nominate *exilis* flushed with golden orange, contrasting sharply with the gray basal area, this golden orange extending over even to the discal brown markings on hindwing; similar in *isophthalma*, the orange duller and less extensive).

Holotype male México, Progreso, Yucatán, 15 October 1958 (E. C. Welling); (♂ genitalia slide no. C-824, CM). Three paratypes, same data; seven paratypes, same locality and collector, XII-3-1962; six paratypes,

Chicxulub Puerto [about 2 km E of Progreso], Yucatán, I-8-1967 (E. C. Welling). All specimens deposited in Carnegie Museum, type series no. 516.

Nominate *Brephidium exilis* has been found over an extremely large area, from Nebraska to Oregon, south in the east to Veracruz and in the west through Baja California, Sonora and Sinaloa. Godman & Salvin (1887, Biol. Centr.-Amer. Rhop. 2: 109) also record it from two salt marshes on the Pacific coast of Guatemala. These specimens should be re-examined to ascertain their subspecific identity.

Large portions of this area are probably inhabited only on a transient basis, for *B. e. exilis* is a great wanderer. It is doubtful that it can overwinter north of central Texas, or above 3–5000 feet elevation southward. The primary residence areas are in coastal salt flats and salt marshes in arid or semi-arid parts of the Lower Sonoran, Subtropical and Tropical life zones. To some extent, particularly from western Texas to California and probably south into Chihuahua and Coahuila, it may also be a permanent resident in interior desert areas.

When Lee D. Miller and I went to eastern Mexico in 1966 one of our objectives was to learn as much as we could about the distribution of *B. exilis* in that region. Between the Brownsville area of southern Texas, where nominate *B. exilis* occurs, and Progreso, Yucatán, where *yucateca* is found, lie roughly a thousand miles of coast from which we knew of not a single record of the species. We surveyed coastal areas in as many places as time and accessibility allowed: in the vicinity of Tampico, on the Tamaulipas-Veracruz border; the long stretch from Tecolutla to Cardel; another stretch from near the city of Veracruz south to beyond Alvarado; and the vicinity of Coatzacoalcos. A few years previously Gary N. Ross had visited the coast near the Tuxtla Mountains to search for *B. exilis* at my request. The results, with one exception, were everywhere the same, no *exilis* was found, and no suitable environment for it. The one exception was a small area 16 miles north of Cardel where we found a few salt flats, in one of which we collected on January 19, 1966 and found a single individual of nominate *B. exilis*. This area is an enclave of semi-arid conditions (desert scrub and thorn scrub on the hills back of the flats) and *B. exilis* is undoubtedly resident here. This locality is widely disjunct from the next suitable area to the north (probably somewhere on the coast of Tamaulipas north of Tampico[1]). There is also a considerable distance between this colony

[1] On our trip we tried to reach this coastal region east of Ciudad Victoria. We got as far as Soto la Marina but were advised that the road from there to the coast, about 30 miles, was impassible.

of nominate *B. exilis* and the nearest known colony of *B. e. yucateca*, which is probably a real distributional gap as the intervening area is too mesic in character.

B. exilis yucateca is most likely restricted to the north coast of Yucatán, another enclave of arid to semi-arid conditions. The new subspecies seems to be most closely related to *B. e. isophthalma* (known from the Bahamas, Cuba, Hispaniola and Jamaica). In many ways *B. e. isophthalma* is intermediate between *B. e. exilis* and *B. e. yucateca.*

Godman & Salvin mention some specimens of *exilis* from Venezuela, and this record is repeated by Draudt (1921, *in* Seitz, Grossschmett. Erde 5: 820). There are two specimens in the Carnegie Museum that may possibly be from Venezuela. They come from the Holland Collection, and Holland obtained them from Staudinger. They bear no locality data, but the same style of labelling occurs on some other material of probable Venezuelan origin. In any event these two specimens seem to represent a new subspecies, nearer to *B. e. yucateca* than to either *B. e. exilis* or *B. e. isophthalma.*

AN INTERESTING NEW SPECIES OF THE NEW WORLD GNORIMOSCHEMINI (GELECHIIDAE) FROM THE LESSER ANTILLES

DALIBOR F. POVOLNÝ
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Several years ago, I had the opportunity of studying interesting material of the tribe Gnorimoschemini in the Naturhistorisches Museum in Vienna. Among their series of this difficult gelechiid group I discovered a small form which I could not identify. After later study of numerous American species (Povolný, 1967) and a detailed consideration of this specimen I decided to describe this moth as a new species belonging to the genus *Keiferia* Busck, 1939.

Keiferia rusposoria Povolný, new species

In general appearance this is a small brownish moth, having the forewings dusted with minute darkish scales, forming an indistinct pattern.

Labial palpus not too slender, lacking scales on second segment, its outer surface markedly grey spotted, inner surface nearly uniform pale cream, third segment pale with two (one basal and one subterminal) rings of dark grey scales. Frons bright,

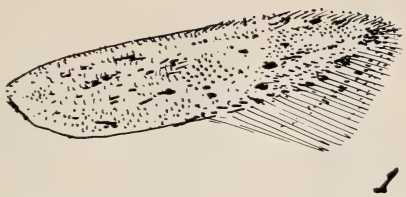


Fig. 1. Pattern of the forewing of *Keiferia rusposoria* Povolný.

patagia brownish. Antennal segments brown with distinct dark rings. Forewing (fig. 1) superficially with ground colour brown; under low magnification individual scales light to brown, mixed with single scales having dark brown to black tips; irregular groups of these dark scales forming an indistinct pattern of dark dots disseminated irregularly over wing; marginal dots around apex more distinct (these dots characteristic of the tribe). Hindwing medium-grey with fine fringe scales; costal margin near base with a group of long, brightly coloured bristles, nearly half as long as costa. Underside of coxae and femora pale cream, nearly uniform, with only isolated dark scales. Tibiae and tarsi markedly bright and dark spotted to ringed.

Length of forewing, 3.8 mm.

Male genitalia (fig. 2) characteristic of the genus *Keiferia* with the heavy thorn-like process on uncus, which is seldom found elsewhere in members of the Gnorimoschemini. Other structures of the male genitalia, especially the sacculus and its processes, also demonstrate the close relationship between the new species and *Keiferia lycopersicella* (Walsingham).

Holotype male: West Indies, Grenada, Balthazar (Windward side), (H. H. Smith) Walsingham Collection, 1910–427 65173. Deposited in Naturhistorisches Museum in Vienna.

Keiferia rusposoria may be best distinguished from the two other members of the genus, *K. lycopersicella* and the very similar *K. elmorei* (Keifer) by differences in the male genitalia (figs. 2, 3). The thorn-like process of the uncus is heavier in the new species than in *K. lycopersicella*, being only a little shorter than the tips of valvae. In *K. rusposoria* the valvae are straight, not S-shaped. The paired processes of the sacculus are present, but the medial pair is tiny with its branches separated by a shallow indentation, whereas the other pair of saccular processes is very long and slender. The saccus is substantially shorter than that of *K. lycopersicella*, being comparatively thick with the tip rounded. The aedeagus is also visibly different from that of *K. lycopersicella*, being shorter without the characteristic inflation of the caecum aedeagi, and moderately curved.

As for the taxonomic position of *K. rusposoria*, it appears clear that the species is congeneric with *K. lycopersicella* but represents a second distinctive morphotype of the genus. From the polyphagous species *K. lycopersicella*, Keifer (1936) distinguished a slightly different species,



Fig. 2. Male genitalia of *Keiferia rusposoria* Povolný, Holotype, Balthazar, Grenada, West Indies.

Keiferia elmorei. The separation of this sibling from *K. lycopersicella* is based on its specialization to indigenous *Solanum* species in California.

Keiferia rusposoria was collected on Grenada, Lesser Antilles, and thus might represent a species originating by long-standing geographic isolation. The native distribution of *K. lycopersicella*, which is referred to as the "tomato pinworm," is not known; as the species has been secondarily introduced as a pest to many parts of Central and South America, and the West Indies, where it perhaps originally did not occur.

The discovery of *K. rusposoria* is therefore of high interest, as it is a

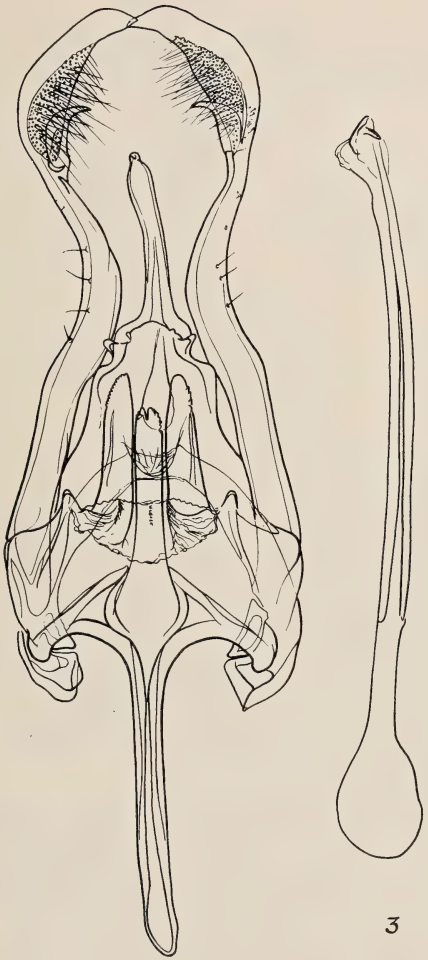


Fig. 3. Male genitalia of *Keiferia lycopersicella* (Walsingham, 1897), Lectotype (British Museum (Natural History) London) St. Croix, Dan. West Indies.

very distinct species of a genus, which appeared to be monomorphic so far.

According to Jerry A. Powell, University of California, Berkeley, to whom I feel greatly obliged for his cooperation in revision of the manuscript, H. H. Smith collected important material of "microlepidoptera" for the British Museum (Natural History) in various parts of the New World before and after the turn of the century. The windward side of the small island Grenada in the Lesser Antilles is the east-facing side.

The specimen might have been sent by Walsingham to Rebel from London to Vienna, because Rebel was dealing also with the former collective genus "*Lita* auct.," to which this species belonged.

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A NEW *PERISAMA* (NYMPHALIDAE: CALLICORINI) FROM BOLIVIA

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During 1962–63, Franz Steinbach, of Cochabamba, Bolivia, consigned to me 395 specimens of *Perisama* Doubleday (including *Orophila* Staudinger) collected near Alto Palmar, Chapare Province, Bolivia. The "*Perisama comnena*" in this group were particularly interesting because they apparently included two distinct phenotypes; one characterized by the normal large red basal patch on the ventral surface of the forewing, the other without it. This is the type of variation that is normally associated with geographical subspecies; however, both forms were sympatric at Alto Palmar. An examination of the male genitalia demonstrated that the two "forms" were in reality distinct species and, after a canvass of the literature, I am of the opinion that the second species is heretofore unnamed.

Perisama rusea Masters, new species

MALE: Upperside of both wings deep-black ground; iridescent green rays extending outwardly from base of forewing, along base of discal cell and vein 2V, until they almost meet a diagonal iridescent green band, 2 to 3 mm wide, which crosses the wing from costal margin, at end of cell to inner margin at tornus; one (occasionally two) iridescent green spot(s) in subapical area, near costal margin. Hindwing with an iridescent green band, 2mm wide, extending through limbal area parallel to outer margin.

Underside of forewing with dull black ground color except for a golden apex; base of wing with a small golden patch, confined primarily to cell and not over 8 mm long, having a tint of red at its outer margin; from this golden patch, a blue-green streak extends along costal margin of cell to a white triangular patch at end of cell which in turn precedes three small blue spots, in cells M_2, M_3 and Cu_1, which form

[1] Research Associate, Section of Insects and Spiders, Carnegie Museum, Pittsburgh.

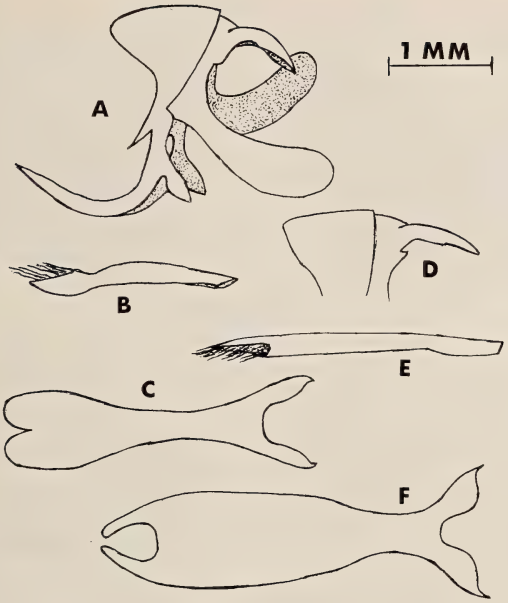


Figure 1. Male genitalia of *Perisama rusea* Masters: (A) left lateral view of genital capsule with inside surfaces shaded; aedeagus (B) removed and the gonostatumen (C) detached and rotated 90° to view ventrally. Male genitalia of *Perisama comnena* Hewitson: (D) left lateral view of uncus and tegumen, (E) aedeagus and (F) ventral view of gonostatumen.

a diagonal line towards tornus. Underside of hindwing a uniform golden base color; two wavy black lines extending from costal margin, where they are at least 2 mm apart, to vannal veins where they stop short of anal margin (the eminens pattern, Schwanwitsch, 1930) with no trace of vestigial eyespots between them.

Male genitalia (figue 1A-C) very distinct from allied species; aedeagus relatively short (approximately 2 mm long) and not over 75% as long as gonostatumen (Dillon, 1948) which is distinctly heart shaped anteriorally.

FEMALE: Similar to male but larger and markings for most part, bolder but with duller colors. The eminens lines, on hindwing underside, meet on costal margin and between them five golden-brown eyespots, in cells M_1, M_2, discal, Cu_1 and Cu_2, faintly visible.

LENGTH OF FOREWING: Male holotype, 21 mm; female allotype, 23 mm.

Holotype male and allotype female: Bolivia, Alto Palmar, Chapare Province, District of Cochabamba, 1,100 meters elevation, March 1963. Types deposited in Carnegie Museum, Pittsburgh.

Paratypes: 22 males from the same locality, various dates, 1962 and 1963. Single paratypes are being placed in the American Museum of Natural History, New York; The U.S. National Museum, Washington; The Museum of Comparative Zoology, Harvard, Cambridge, Massachu-

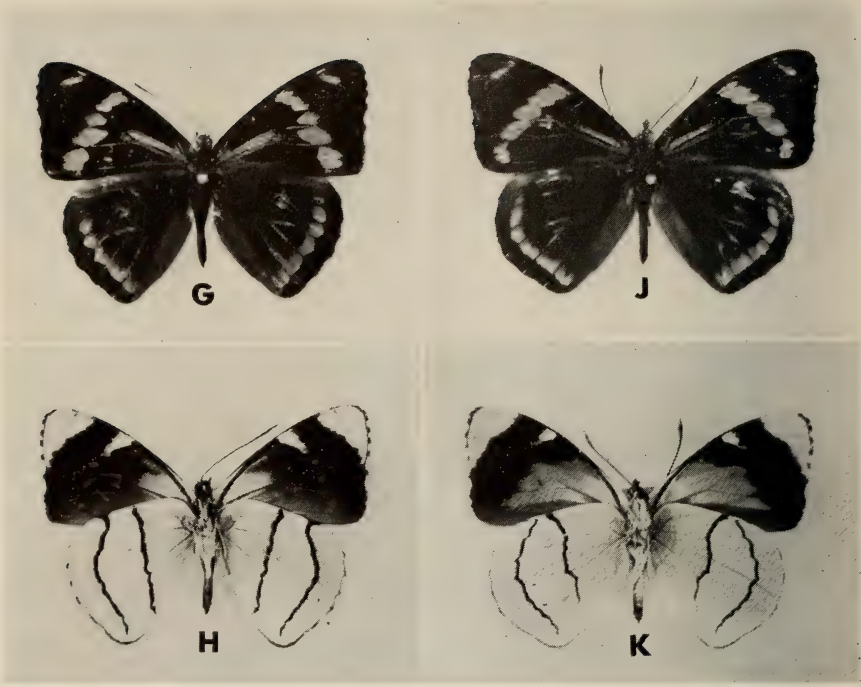


Figure 2. *Perisama rusea* new species, paratype male, Alto Palmar, Chapare, Bolivia, March 1963: (G) upperside and (H) underside. *Perisama comnena* Hewitson, Alto Palmar, Chapare, Bolivia, April 1963: (J) upperside and (K) underside.

setts; and the Reading Public Museum, Reading, Pennsylvania. The remainder are being retained in the author's collection.

Perisama rusea (figure 2G-H) is immediately distinguishable from *Perisama comnena* Hewitson (figure 2J-K) by the lack of the large red basal spot on the ventral surface of the forewings; from *Perisama xanthica* Hewitson by the presence of the green limbal band on the dorsal surface of the hindwing and by a much smaller golden patch at the base of the ventral surface of the forewing; and from *Perisama humboldtii* Guer. by the lack of punctiform eyespots on the ventral surface of the hindwing and a large red basal spot on the ventral surface of the forewing. All four of these species are sympatric at Alto Palmar, Bolivia and all have distinctive male genitalia. Examination of several series of *P. comnena* from Peru did not reveal any *P. rusea* among them.

Examination of the male genitalia in *Perisama* and related genera (Callicorini) reveals that the uncus, tegumen, saccus, aedeagus and

gonostatumen all have diagnostic characters at the species level. It is suprising that previous use has not been made of them. In his revision of the Callicorini (as Catagrammini), Dillon (1948) characterized the male genitalia in his definition of the tribe, but did not use them to diagnose species. The gonostatumen is an interesting structure that is found only in the Callicorini, including *Callithea* Feisthamel. It was named by Dillon (1948) who believed it to be a modification of the eighth sternite and to function as a prop for the usual genital organs.

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MULTIPLE CAPTURE OF *CARIA INO MELICERTA* (RIODINIDAE) AT LIGHT

Lee D. Miller

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A rather extensive bibliography has accumulated concerning butterflies that have been attracted to light. Most recent records have been of captures at ultraviolet light, such as reported by Throne (1961) and Welling (1963). Most of these records involve single specimens, but there have been a few instances of multiple captures of butterflies (Donahue, 1962; Phillips, 1962; Welling, 1963; and Hessel, 1965), for example. Some of the collections have been at ultraviolet light, some at fluorescent and a few at incandescent light.

There seem to be two explanations for the attraction of butterflies to light: (1) the butterflies were at rest, were disturbed and these flew to the light source, and (2) the butterflies are crepuscular species and were attracted to the light as are many crepuscular Sphingidae and other moths. Most of the records fall into the first category, and they almost always are based on one or two specimens; the majority of the captures I have made at light are in this class, both in the United States and in the Neotropics. Several of the multiple captures, especially those of *Opsiphanes* (Welling, 1963) and *Melanitis* (Donahue, 1962), are of

crepuscular species, and the captures of *Hypaurotis* reported by Hessel (1965) involve a species that is definitely not heliophilic during midday hours and continues activity into evening (*e.g.*, Chambers, 1963).

During July and August, 1966, I taught a travelling field biology course, and the students and I often trapped moths at ultraviolet light as part of the activities without taking any butterflies. The evening of August 2nd we set up the light at Bentsen-Rio Grande State Park, Hidalgo County, Texas, on a hot (*ca.* 85° F.), muggy night, and collecting was excellent for moths and other insects. The effectiveness of the ultraviolet lamp was attested to by the fact that very few insects were attracted to the Coleman lantern we used as a camp light about a hundred feet from the moth sheet. I was surprised, therefore, to see a specimen of *Caria ino melicerta* Schaus, a riodinid, flop down on the table next to the lantern and begin walking slowly over the surface of the tabletop gently opening and half closing its wings until I bottled it. A short time later one of the students took a second specimen at the Coleman lantern, and still later I captured two more specimens that were behaving in the same manner as the first. Another of the students also collected a specimen at an incandescent light in one of the park bath houses. All five *melicerta* were taken between 9:00 and 11:00 P.M., C.D.T. A check of the insects collected at the ultraviolet light revealed no butterflies, even though hundreds of moths had been taken.

I collected only a single female of *C. i. melicerta* in two days of collecting in the same area in which the five specimens were collected at light. This specimen was netted in deep woods resting under a leaf, and it looked as though this species was crepuscular, or at least heliophobic. Two hours' collecting at Bentsen park in September, 1967, yielded about fifty specimens at flowers in the brightest sunlight, so *C. i. melicerta* is not consistently crepuscular or heliophobic.

These records of this butterfly, I believe, are the first to demonstrate any butterfly making a "choice" between visible and ultraviolet light, and it is intriguing that these insects selected the visible light source. I have been unable to obtain spectroscopic analyses of the light from a Coleman lantern, but I suspect that the ultraviolet component is minor, as is that of an incandescent light. This demonstrates a phenomenom that is well known, but seldom stated: some insects that will come to visible light are not attracted to ultraviolet light. The advent of ultraviolet light as a collecting aid has greatly increased the numbers of both individuals and species that may be taken during a night's collecting, but many species of Lepidoptera cannot be obtained by this method.

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BIONOMIC NOTES ON HAETERINI AND BIINI IN VENEZUELA (SATYRIDAE)

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Haeterini

Four genera, *Pierella* Westwood, *Haetera* Fabricius, *Dulcedo* d'Almeida and *Cithearias* Hübner (= *Callitaera* Butler), comprise the Haeterini, the most primitive tribe of Satyridae. All of the Haeterini have distinctive wing shapes with short, narrow forewings and seemingly enlarged hindwings. *Haetera, Cithearias* and *Dulcedo* are the only clear-winged Satyridae (see Figure 1, *Cithearias andromeda* Fabricius). All of the known species are Neotropical and are found on the forest floors of dense tropical and subtropical forests.

Virtually nothing has been published concerning the habitat and habits of these butterflies. I have found only brief notes by Weymer (*in*: Seitz, 1909) and Brown (1942). Both mention that these satyrids inhabit forested areas, fly near the ground and are difficult to see or follow in flight. Weymer mentions that members of the genus *Cithearias* (given as *Callitaera*) prefer the early morning hours for flight.

After having the opportunity to observe several of these species in Venezuela (1965 and 1966 in Bolivar and 1968 in Barinas), I can add somewhat to these statements. Determinations of my specimens were made by Michael Clifton of the British Museum (Natural History) who is currently preparing a taxonomic revision of the tribe.

The species that I observed seemed to be strictly limited to denser

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Figure 1. *Cithearias andromeda* Fabricius. 88 kilometers south of El Dorado, Bolivar, Venezuela; 20 Feb. 1966 (J.H.M.) Natural Size.

selva (low and tropical forests) where they flew close to the forest floor and nearly always lit on the ground. They were distinctly matinal and crepuscular in habit, flying during both early morning and evening hours. However, *Pierella* species, and to a lesser extent the others, would fly throughout the day during inclement weather. All of the species were attracted to fruit, but to catch them at it was difficult. Normally fruit bait is placed in the center of a small area from which all leaves and underbrush have been cleared and then those species that are attracted, including *Taygetis, Euptychia, Caligo, Morpho*, etc., are easily netted. *Haetera* and *Cithearias* species are attracted to fruit but will not alight in a cleared patch of ground but will alight around its edge instead where they can be perfectly camouflaged. Of course, if the bait is placed on uncleared ground, they blend into the background so well that they are completely inconspicuous while visiting it. The use of bait traps would seem to be the answer (for a description of bait traps and their use see Rydon, 1964), but the effectiveness of most traps depends upon butterflies to fly upward when disturbed. While most butterflies do fly upward when disturbed, the Haeterini fly horizontally and close to the ground and thus cannot be taken in any ordinary sort of trap. The best method of collecting them is to spread fruit on the ground to attract them into the area, and to then walk through the tract at dusk flushing them and carefully stalking them.

Haetera piera piera (Linnaeus)

This species was encountered in heavy selva in both Bolivar and Barinas. *H. piera*, with transparent wings just shaded with yellow, appears ghost-like in flight, just a flicker of yellow moving across the

leaves. They fly slowly and alight often, but it is difficult for the eye to follow them in flight and, unless you actually see them alight, they are virtually impossible to detect on the ground. They were usually encountered as solitary individuals, but the presence of fruit (natural or bait) on the forest floor would concentrate them into a given area. In 1966, a single male of *piera* was taken at heliotrope (Masters, 1968), a bait normally employed to attract Ithomiidae. This might be another source of evidence of the close phylogenetic relationship of these primitive Satyridae to the Ithomiidae, a relationship pointed out by Fox (1956). However rather than being attracted to the heliotrope the satyr was probably attracted to traces of fruit on it as heliotrope and fruit baits had been spread along the trail at the same time.

Cithearias andromeda Fabricius

Cithearias andromeda (= *esmeralda* Dbl.) was found in the same habitat in Bolivar as *H. piera* but was much scarcer and less apt to venture into an open area. *C. andromeda* (figure 1) also has transparent wings, but shaded with purple instead of yellow, a combination that makes it even more difficult to observe and follow in the selva. Its flight is also slow, and apparently its primary defence against predation is the inconspicuous character of nearly colorless, transparent wings.

Pierella astyoche Erichson

This species was encountered in heavy selva in Bolivar but was much more prone to come out along trails or to enter small clearings, thus being much more in evidence and more frequently encountered than *H. piera* or *C. andromeda*. *Pierella astyoche* is a quite active flier and males are fond of flying quickly up and down a forest trail close to the ground. Each male seemed to have its own section of path to patrol and this activity suggests a form of reconnaissance for females. Interest in patrolling decreased when fruit was spread on the trail and *astyoche* was less shy in coming to bait than the clear-winged species. The best method of capturing them, however, was to note the path of a patrolling male and to then wait along it to intercept the butterfly in flight. Peak flight for *P. astyoche* was from late afternoon until dusk, but a few individuals seemed to fly throughout the day. On cloudy days they would fly in numbers all day long, and, along with *Taygetis* species, would be virtually the only butterflies encountered on the forest floor.

Pierella hyalinus hyalinus Gmelin

Pierella hyalinus is a large attractive species with deep blue on the

hindwings. *P. hyalinus* is sympatric with *astyoche* in Bolivar and has similar habits, but the two could be readily distinguished on the wing because of the large size and blue of the rarer *hyalinus*.

BIINI

A single unique species, *Bia actorion* (L) (= *actoriaena* Hübner), comprises the Biini.

Bia actorion actorion (Linnaeus)

The geographical range of *Bia actorion* is limited to the lowland rain forests of the Amazon and Orinoco basins. I found the specific habitat preference of *B. actorion* to be those areas where enough sun penetrates to the forest floor to provide a thick and heavy undergrowth rather than those areas where the canopy is complete and prevents enough sunlight to reach the ground to allow for much undergrowth. Solitary individuals of *B. actorion* were encountered along trails or in clearings where they would alight about three feet above the ground among underbrush. They quickly fly to the base of a bush when alarmed where they are either perfectly concealed or impossible to get at with a net. *Bia actorion* is very striking during flight because of the nearly iridescent upper wings that flash in the sunlight, giving the appearance of a miniature *Morpho*. When the insect alights, the flashing blue suddenly disappears, which undoubtedly adds to the deception as the cryptic undersides blend into the background.

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STUDIES ON THE BIOLOGY AND SEASONAL HISTORY OF *POLYDORUS ARISTOLOCHIAE* (PAPILIONIDAE)

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Polydorus aristolochiae (Fabricius) is the commonest large tailed, black butterfly of Indo-Pakistan Subcontinent. At Tandojam, West Pakistan the larvae have been found in large numbers on *Aritolochia bracteata*. The biology of this insect has been studied only by Ghosh (1914). The observations recorded by us concerning this species are given in the present paper. The work was under taken during 1962–63 at Tandojam.

Egg

Description

The eggs of *Polydorus aristolochiae* are laid on the underside, very rarely on the upper surface, of host leaves. A high oviposition rate was observed in the months of August and September and again during March and April. Up to five eggs were collected from each leaf.

The chorion is covered with a reddish brown, soft gum like substance, in minute granular masses. The latter are arranged somewhat in undulating ridges meeting at a point. These give the egg the appearance of a citron with the long axis slightly shorter and a little inclined towards one side and never perpendicular to the leaf surface.

Incubation Period

Since the butterflies did not lay eggs in captivity, the incubation period was determined by recording the maximum period required for hatching of eggs collected in the field. The time taken for hatching of the eggs is given in Table 1.

Ghosh (1914) recorded that the incubation period is four to five days from June to September. The results obtained here are in general agreement with his observations. Between the months of October and March the incubation period is longer due to lower temperatures.

Larva

The larva is dark brown, and passes through four instars. The duration of larval stages was studied in the laboratory. The results are presented in Table 2.

It can be seen from table 2 that the duration of larval life varies from 14 to 62 days. The minimum duration was for larvae which hatched in September, 1962. Those hatching in the early part of January, 1963,

TABLE 1. INCUBATION PERIOD OF EGGS OF *Polydorus aristolochiae* COLLECTED IN THE FIELD

Month	Days required for hatching of eggs	Estimated incubation period in days	Average monthly Temperature (Fahrenheit)
September	2–5	5 Days	75.91
October	3–9	9 Days	69.64
November	2–9	9 Days	73.78
December	2–9	13 Days	60.88
January	8–13	13 Days	60.92
February	4–10	10 Days	69.92
March	3–10	10 Days	75.65
April	2–6	6 Days	83.75

passed their development during the two coldest months and, hence, their development required 62 days.

Ghosh (1914) has described the prolongation of larval life as hibernation. During our studies at Tandojam, however, larvae continued to feed during this period.

PUPA

The length of the pupal period varied from 10 to 230 days as is shown in Table 3.

The duration of the pupal stage is not correlated with atmospheric temperature (Table 1). Ghosh (1914) observed the pupal period to last from 10 to 303 days, and the present observations are in general agreement. However, Ghosh mentions that the insect undergoes a hibernation followed by an aestivation. This deduction does not seem to be correct since adult emergence took place in the coldest period as well as in hot months. Further, pupae from the same batch required widely varying

TABLE 2. LENGTH OF LARVAL LIFE OF *P. aristolochiae*

Month in which egg hatched	Larval life (in days)
September	14–15
October	22–25
November	24–31
December	31–43
January	50–62
February	26–35
March	26–35
April	28–34

Table 3. Pupal period of *P. aristolochiae*

Month in which larva pupated	Pupal period (in days)
August	10
September	13–230
October	13–228
November	19–150
December	36–141
January	44–143
February	14–179
March	13–172
April	12–38

periods before emergence of the adult, and it emergence by later pupating individuals sometimes occurred while from pupae of an earlier batch emergence of butterflies had not taken place. Thus, there is great range of individual variation in the pupal period, without apparent effect of temperature.

The above conclusion is corroborated by observations on pupae collected in the field. One hundred forty pupae were collected on November 5 and 25, 1962, from a small area at Tandojam which was under constant observation. Pupation had taken place on 5th and 25th November respectively.

Life Cycle

According to the observations made on the length of incubation, larval and pupal periods (Tables 1–3), it is seen that the butterfly

Table 4. Emergence of adults from field collected pupae

Date of collection	Month of adult emergence	Pupal period (in days)
5 Nov. 1962	February	88–115
	March	127–146
	April	153–176
	May	184–207
	June	215–224
	July	246–258
	August	275
25 Nov. 1962	December	23
	January	51
	February	72
	March	120
	April	146
	May	166–176

requires from one to about 9 months to complete its life cycle (exclusive of adult).

It may, therefore be concluded that the insect may have up to about 7 overlapping generations in a year. Normally, in the field it probably has fewer.

Field surveys revealed the presence of all the stages on the host plants throughout the year.

NATURAL ENEMIES

Thompson (1946) reported *Apanteles aristolochiae* Wlkn. as a parasite of this butterfly. No parasites of eggs or larvae were found during this study.

ACKNOWLEDGMENT

To Jerry A. Powell, University of California, Berkeley, we wish to express our sincere appreciation for correcting and improving the manuscript.

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A NEW *CALLITHOMIA* (ITHOMIIDAE) FROM BOLIVIA

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During 1962–1965 I received several large consignments of Bolivian Ithomiidae from Franz Steinbach of Cochabamba, Bolivia. Perhaps the most interesting specimen among these is an unique and previously undescribed *Callithomia*. The late Dr. Richard M. Fox, acknowledged expert in the Ithomiidae, examined this specimen, recognized it as a new species and intended eventually to describe it himself. With the death of Dr. Fox on April 28th, 1968, I have assumed the task of describing the insect and take pleasure in naming it after him.

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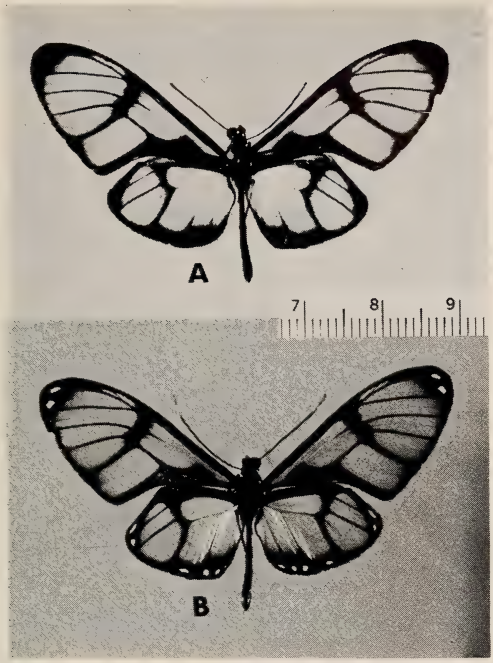


Figure 1. *Callithomia foxi* Masters. Holotype male: A, upperside; B, underside.

Callithomia foxi Masters, new species

MALE: Upperside of both wings (figure 1A) transparent with black markings outlining veins and wing margins. Black markings widening on both wings at costal and inner margins, wing apices, at end of discal cells and along vein Cu_1. Cu on hindwing and basal parts of veins Cu_2 and 2V yellow. Inner margin of forewing sharply concave. Costal margin of hindwing sharply humped at raised oval "*Ithomia* patch" from there concave to outer angle.

Underside of wings (figure 1B) a mirror image of upperside except for eight small white spots in black wing margins—two at apex of forewing (also a dimunitive in M_2), four at anal angle and two at apex of hindwing. Transparent areas with a yellowish cast, viewed from below.

Male genitalia figured (figure 2).

LENGTH OF FOREWING: base to tip, 29 mm.

FEMALE: Unknown.

Holotype male: Bolivia, Todos Santos, Prov. Chapare, Dpto. Cochabamba (300 meters elevation), July 1964. Deposited in Carnegie Museum, Pittsburgh, Pennsylvania.

Dr. Fox (*in litt.*) believed that this specimen was the only example of the species in American collections, but noted that there were a couple of examples resting unnamed in European collections. The subterminal spine on the aedeagus places *Callithomia foxi* in that section of the genus

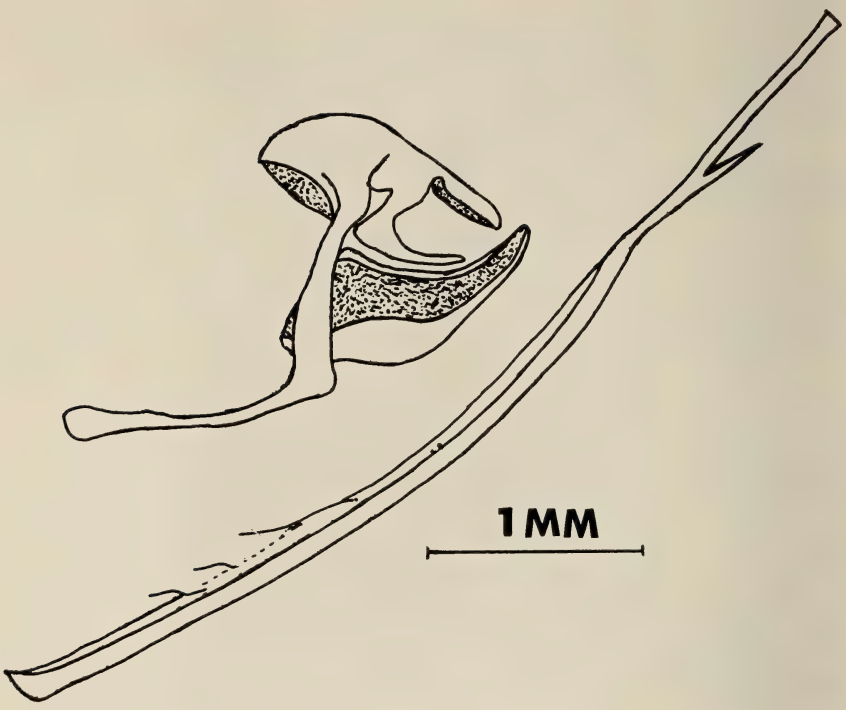


Figure 2. *Callithomia foxi* Masters male genital structure. Aedeagus removed and shown below. Left valva removed and not shown.

that includes *xantho* (Felder), *methonella* (Weymer), *inturna* (Fox), *epidero* (Bates), *lenea* (Cramer), *drogheda* (Weeks) and *zingiber* Fox. Of these seven, *C. epidero*, *methonella*, *xantho* and *interna* have a strong resemblance to *C. foxi*. *Callithomia xantho* and *interna*, and to a lesser extent *methonella*, are separable by the lack of heavy black scaling along vein Cu_1 and the end of the cell, this is especially noticeable on the hindwings. *Callithomia epidero* and *methonella* have red to brown patches at the anal angle of the hindwing, that are lacking in *C. foxi*. None of the species in the other section of the genus have a similar appearance.

AN OBSERVATION ON THE USE OF COLOR FOR SPECIES-RECOGNITION IN *HELICONIUS BESCKEI* (NYMPHALIDAE)

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Crane (1955) has shown red to be an important courtship releaser in *Heliconius erato hydara* Hewitson, and Swihart (1963, 1964) has confirmed the significance of red in that species by neurophysiological techniques.

During the course of genetical studies on *Heliconius*, living specimens of the mimetic pair, *Heliconius erato phyllis* (Fabricius) and *H. besckei* Ménétriés, from Rio de Janeiro, Brazil, were caged with specimens of *H. melpomene melpomene* (Linnaeus) from Trinidad. Both *H. e. phyllis* and *H. besckei* have red forewing bands and a yellow hindwing bar, but *H. m. melpomene* has only red forewing bands. All colors are on a black background.

It was observed that male *erato phyllis* and male *melpomene* would each fly towards members of either of the other two species in the cage, but presumably because secondary courtship releasers were lacking they would then disengage and fly off (all the females had already been mated). *H. besckei*, however, though appearing in good health, would only pursue the *phyllis*, not the *melpomene*. The color difference between these two is the lack of yellow in *melpomene*. The courtship releaser is known to be red in *erato* and is likely also to be red in *melpomene*. Possibly it is yellow in *besckei*.

Whether the courtship releaser in *besckei* is red or yellow is an important behavioral character which should be considered in deducing the course of the evolution of mimicry in *Heliconius*.

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A REVISED SYNONYMIC CATALOGUE WITH TAXONOMIC NOTES ON SOME NEARCTIC LYCAENIDAE

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INTRODUCTION

The publication by Harry K. Clench ([1961]: 177–220) and John C. Downey ([1961]: 230–242) *in* Ehrlich & Ehrlich's *How to Know the Butterflies* of revisions of the Theclini by the former and the Plebejini by the latter rendered another part of the present author's synonymic list (1964), at least obsolete insofar as the Theclini is concerned. This situation is similar to the one explained in a previous paper on the Nearctic Melitaeinae (1969, J. Lepid. Soc., 23: 115–125).

Clench revised the Theclini and in the course of his work proposed eight new generic or subgeneric names, besides introducing into our fauna some names that had heretofore been considered Neotropical and eliminating some that are no longer considered Nearctic. Downey, on the other hand, merely rearranged the order in which the genera and some of the species appear in the synonymic list so that it is not considered necessary to repeat his work, no reasons having been given for such action. Clench also made no vital changes in this author's Lycaeninae which he gives tribal rank (Lycaenini) except that he combines *Lycaena cupreus* with *L. snowi* (1961: 222) as one species although recognizing apparently both as good subspecies. Also he does not clearly recognize the subgenus *Tharsalea* Scudder, 1876, although he may recognize it subgenerically in another faunal area, and arranges the species in *Lycaena* in somewhat different order. These are subjective matters with which one cannot quarrel, but in neither case is it deemed necessary to rewrite those parts of the synonymic list.

Neither Clench's nor Downey's works give any synonymies and do not list categories lower than species. This was done in accordance with the wish of the authors of *How to Know the Butterflies*, but is unfortunate for the student because he cannot tell what has become of subspecies, lower categories, and synonyms.

The present paper follows the general style and form of the synonymic list, followed by notes giving explanations for the changes made. An effort has been made to fit all names into the list by giving numbers to them starting with 349 where the Lycaenidae start. A similar arrangement of the genera was impossible because of the many changes made by Clench.

The thorough and badly needed revision of the Theclini by my colleague Harry K. Clench, Curator of Lepidoptera at the Carnegie Museum, is of such value and importance that it should be made available in catalogue form to purchasers of the synonymic list. My thanks are extended to Mr. Clench for clearing up some points that were uncertain in his work or not easily understood. He has been most liberal in his assistance.

I am indebted also to my colleague, F. Martin Brown, for placing at my disposal a *ms* on the types of the Lycaenid butterflies described by William Henry Edwards of which he is the senior author with Paul A. Opler. Brown generously gave permission to use any of his ideas.

Family **LYCAENIDAE**
Subfamily **THECLINAE**

HABRODAIS Scudder, 1876

Type: *Thecla grunus* Boisduval, 1852
Habrodias McDunnough, 1914 (*lapsus calami*)

349 **grunus** (Boisduval), 1852
a **g. grunus** (Boisduval), 1852
b **g. lorquini** Field, 1938
form *chloris* Field, 1938
c **g. herri** Field, 1938

HYPAUROTIS Scudder, 1876

Type: *Thecla chrysalus* Edwards, "1872–3" (1873) (= *Thecla crysalus* Edwards, "1872–3" [1873])

350 **crysalus** (Edwards), "1872–3" (1873)
chrysalus Auctorum
chryaslus (Edwards), 1884 (*lapsus calami*)
form *citima* (H. Edwards), 1881

CHLOROSTRYMON Clench, [1961]

Type: *Thecla telea* Hewitson, 1868

*351 **simaethis** (Drury), "1770" [1773]
a **s. sarita** (Skinner), 1895
352 **telea** (Hewitson), 1868
353 **maesites** (Herrich-Schäffer), 1864

PHAEOSTRYMON Clench, [1961]

Type: *Thecla alcestis* Edwards, "1870–1" (1871)

354 **alcestis** (Edwards), "1870–1" (1871)
a **a. alcestis** (Edwards), "1870–1" (1871)
b **a. oslari** (Dyar), 1904

HARKENCLENUS nom. nov.

pro *Chrysophanus* Hübner, 1818 (opinion 541, name 1235)

Type: *Chrysophanus mopsus* Hübner, 1818 (opinion 541, name 1235)
(= *Papilio titus* Fabricius, 1793) (opinion 541, name 1605)

355 **titus** (Fabricius), 1793
- a **t. titus** (Fabricius), 1793
- b **t. mopsus** (Hübner), "1818" [1809–13]
- c **t. watsoni** (Barnes & Benjamin), 1926
- d **t. immaculosus** (Comstock), 1913

SATYRIUM Scudder, 1876

Type: *Lycaena fuliginosa* Edwards, 1861
Callipsyche Scudder, 1876
Strymon Auctorum (*partim*)
Thecla Auctorum (*partim*)

356 **fuliginosum** (Edwards), 1861
- a **f. fuliginosum** (Edwards), 1861
 suasa (Boisduval), 1869
 ab. *immaculata* Gunder, 1927
- b **f. semiluna** Klots, 1930

357 **behrii** (Edwards), "1870–1" (1870)
- a **b. behrii** (Edwards), "1870–1" (1870)
 kali (Strecker), "1872" [1878]
 ab. *nigroinita* (Gunder), 1924
- b **b. crossi** (Field), 1938
- c **b. columbia** (McDunnough), 1944

358 **auretorum** (Boisduval), 1852
- a **a. auretorum** (Boisduval), 1852
 tacita (H. Edwards), 1881
- b **a. spadix** (H. Edwards), 1881

359 **tetra** (Edwards), "1870–1" (1870)
adenostomatis (H. Edwards), 1877

360 **saepium** (Boisduval), 1852
chalcis Edwards, "1868–9" (1869)
soepium (Boisduval), 1852 (*lapsus calami*)
- a **s. saepium** (Boisduval), 1852
 form *fulvescens* (H. Edwards), 1877
 form *chlorophora* (Watson & Comstock), 1920
 form *provo* (Watson & Comstock), 1920
- b **s. okanagana** (McDunnough), 1944

361 **liparops** (Le Conte), [27 July 1833]
- a **l. liparops** (Le Conte), [27 July 1833]
- b **l. strigosa** (Harris), 1862
 - ab. *pruina* (Scudder), 1889
- c **l. fletcheri** (Michener & dos Passos), 1942
 - *liparops* (Fletcher *nec* Le Conte [27 July 1833]) "1903" [1904]
- d **l. aliparops** (Michener & dos Passos), 1942

362 **kingi** (Klots & Clench), 1952

363 **calanus** (Hübner), "1806" [1809]
- *wittfeldii* (Edwards), 1883
- a **c. calanus** (Hübner), "1806" [1809]
- b **c. falacer** (Godart), "1819" [1824]
 - *lorata* (Grote & Robinson), 1867
 - *inorata* (Grote & Robinson), 1867
 - ab. *heathii* (Fletcher), "1903" [1904]
- c **c. godarti** (Field), 1938

364 **caryaevorus** (McDunnough), 1942

365 **edwardsii** (Saunders), 1869
- *fabricii* (Kirby), 1871

366 **sylvinus** (Boisduval), 1852
- a **s. sylvinus** (Boisduval), 1852
- b **s. desertorum** (Grinnell), 1917
- c **s. itys** (Edwards), 1882
- d **s. putnami** (H. Edwards), 1877
 - *putmani* Brown, Eff, & Rotger, 1955 (*lapsus calami*)

367 **californica** (Edwards), 1862
- *borus* (Boisduval), 1869
- *cygnus* (Edwards), "1870–1" (1871)

368 **acadica** (Edwards), 1862
- *acadia* Brown, Eff, & Rotger, 1955 (*lapsus calami*)
- a **a. acadica** (Edwards), 1862
 - *souhegan* (Whitney), 1868
 - *souhegon* (McDunnough), 1938 (*lapsus calami*)
 - ab. *muskoka* (Watson & Comstock), 1920
 - ab. *swetti* (Watson & Comstock), 1920
- b **a. coolinensis** (Watson & Comstock), 1920
- c **a. montanensis** (Watson & Comstock), 1920
- d **a. watrini** (Dufrane), 1939

369 **dryope** (Edwards), "1870–1" (1871)

EUMAEUS Hübner, "1816" [1819]

Type: *Eumaeus minyas* Hübner, "1816" [1819] (= *Rusticus adolescens minijas* Hübner, "1806" [1809])
Eumenia Godart, "1819" [1824]

*370 **atala** (Poey), 1832
a **a. florida** Röber, 1926
grayi Comstock & Huntington, 1943

371 **minyas** (Hübner), "1816" [1819] (*emendatio*)
minijas (Hübner), "1806" [1809]
toxea (Godart), "1819" [1824]

OENOMAUS Hübner, "1816" [1819]

Type: *Papilio ortygnus* (Cramer), "1782" [1779]

372 **ortygnus** (Cramer), "1782" [1779]

MINISTRYMON Clench, [1961]

Type: *Thecla leda* Edwards, 1882

373 **ines** (Edwards), 1882

374 **leda** (Edwards), 1882

375 **clytie** (Edwards), 1877
gen. hiem. maevia (Godman & Salvin), (1887)

HETEROSMAITIA Clench, 1964

Type: *Thecla bourkei* Kaye, 1924

376 **spurina** Hewitson, "1862" [1867]

377 **zebina** (H. A. Freeman), 1950

CALYCOPIS Scudder, 1876

Type: *Rusticus armatus poeas* Hübner, "1806" [1811] (= *Hesperia cecrops* Fabricius, 1793)

378 **beon** (Stoll), 1782

379 **cecrops** (Fabricius), 1793
poeas (Hübner), "1806" [1811]
ab. *gottschalki* (Clark & Clark), 1938

TMOLUS Hübner, "1816" [1819]

Type: *Papilio echion* Linnaeus, 1767

380 **echiolus** (Draudt), 1920
echion Auctorum (*nec* Linnaeus, 1767)

381 **azia** (Hewitson), 1873
nipona Auctorum (*nec* Hewitson, 1877)

CALLOPHRYS (INCISALIA) Scudder, 1872

Type: *Licus niphon* Hübner, [1819–] 1823 [1823]

382 **polios** Cook & Watson, 1907
ab. *davisi* Watson & Comstock, 1920
383 **irus** (Godart), "1819" [1824]
a **i. irus** (Godart), "1819" [1824]
arsace (Boisduval & Le Conte), [1833]
ab. *baltaeta* Scudder, 1889
balteata dos Passos, 1964 (*lapsus calami*)
b **i. hadros** Cook & Watson, 1909
384 **henrici** (Grote & Robinson), 1867
a **h. henrici** (Grote & Robinson), 1867
b **h. turneri** Clench, 1943
c **h. margaretae** dos Passos, 1943
d **h. solatus** Cook & Watson, 1909
385 **fotis** (Strecker), "1877" [1878]
a **f. mossii** (H. Edwards), 1881
b **f. schryveri** Cross, 1937
c **f. bayensis** R. M. Brown, 1969
d **f. doudoroffi** dos Passos, 1946
e **f. windi** Clench, 1943
f **f. fotis** (Strecker), "1877" [1878]
386 **augustinus** (Westwood), "1846–52" [1852]
augustus (Kirby *nec* Fabricius, 1793), 1837
a **a. augustinus** (Westwood), "1846–52" [1852]
b **a. helenae** dos Passos, 1943
c **a. croesioides** Scudder, 1876
d **a. iroides** (Boisduval), 1852
ab. *immaculata* (Cockle), 1910
e **a. annetteae** dos Passos, 1943
387 **lanoraieensis** Sheppard, 1934
388 **niphon** (Hübner), [1819–] 1823 [1823]
nipha (Morris), 1860 (*lapsus calami*)
a **n. niphon** (Hübner), [1819–] 1823 [1823]
plautus (Scudder), 1876
b **n. clarki** Freeman, 1938
389 **eryphon** (Boisduval), 1852
a **e. eryphon** (Boisduval), 1852
b **e. sheltonensis** Chermock & Frechin, "1948" [1949]

CALLOPHRYS (SANDIA) Clench & Ehrlich, 1960

Type: *Callophrys (Sandia) mcfarlandi* Ehrlich & Clench, 1960
390 **macfarlandi** Ehrlich & Clench, 1960 (*emendatio*)
mcfarlandi Ehrlich & Clench, 1960

CALLOPHRYS (XAMIA) Clench, [1961]

Type: *Thecla xami* Reakirt, "1866" [1867]

391 **xami** (Reakirt), "1866" [1867]
blenina (Hewitson), 1868

CALLOPHRYS (MITOURA) Scudder, 1872

Type: *Thecla smilacis* Boisduval & Le Conte, [1833] (= *Papilio damon* Stoll, 1782 *nec* [Denis & Schiffermüller], 1775 = *Lycus gryneus* Hübner, "1816" [1819])

392 **loki** (Skinner), 1907

393 **hesseli** Rawson & Ziegler, 1950

394 **gryneus** (Hübner), "1816" [1819]
a **g. gryneus** (Hübner), "1816" [1819] (*gen. vern.*)
damon (Stoll *nec* [Denis & Schiffermüller], 1775), 1782
demon (Skinner), 1897 (*lapsus calami*)
damastus (Godart), "1819" [1824]
auburniana (Harris), 1862 (*partim*)
ab. *octoscripta* Buchholz, 1951
gen. aest. smilacis (Boisduval & Le Conte), [1833]
auburniana (Harris), 1862 (*partim*)
patersonia (Brehme), 1907
b **g. sweadneri** Chermock, "1944" [1945]
c **g. castalis** (Edwards), "1870–1" (1871)
discoidalis (Skinner), 1897
form *brehmei* Barnes & Benjamin, 1923

395 **spinetorum** (Hewitson), 1867
ninus (Edwards), "1870–1" (1871)
cuyamaca (Wright), 1922

396 **siva** (Edwards), "1874–6" (1874)
a **s. siva** (Edwards), "1874–6" (1874)
rhodope (Godman & Salvin), (1887)
b **s. juniperaria** J. A. Comstock, 1925
c **s. mansfieldi** Tilden, 1951

397 **nelsoni** (Boisduval), 1869
a **n. nelsoni** (Boisduval), 1869
ab. *exoleta* (H. Edwards), 1881
b **n. muiri** (H. Edwards), 1881

398 **johnsoni** (Skinner), 1904

CALLOPHRYS (CALLOPHRYS) Billberg, 1820

Type: *Papilio rubi* Linnaeus, 1758

Lycus Hübner, "1816" [1819] (*nec Lycus* Fabricius, 1787)
Licus Hübner [1819–] 1823 [1823]

399 **affinis** (Edwards), 1862
a **a. washingtonia** Clench, 1944
b **a. affinis** (Edwards), 1862

400 **sheridanii** (Carpenter), 1877 (*emendatio*)
sheridonii (Carpenter), 1877 (*lapsus calami*)
a **sheridanii** (Carpenter), 1877 (*emendatio*)
b **s. neoperplexa** (Barnes & Benjamin), 1923
c **s. newcomeri** Clench, 1963

401 **dumetorum** (Boisduval), 1852
a **d. dumetorum** (Boisduval), 1852
perplexa Barnes & Benjamin, 1923

402 **apama** (Edwards), 1882
a **a. apama** (Edwards), 1882
b **a. homoperplexa** Barnes & Benjamin, 1923

403 **comstocki** Henne, 1940

404 **lemberti** Tilden, 1963

405 **viridis** (Edwards), 1862

CALLOPHRYS (CYANOPHRYS) Clench, [1961]

Type: *Strymon agricola* Butler & Druce, 1872

406 **miserabilis** Clench, 1946
pastor Auctorum (*nec* Butler & Druce, 1872)

407 **goodsoni** (Clench), 1946
facuna Auctorum (*nec* Hewitson, 1877)

ATLIDES Hübner, "1816" [1819]

Type: *Papilio halesus* Cramer, "1779" [1777]
Brangas Hübner, "1816" [1819]

408 **halesus** (Cramer), "1779" [1777]
a **h. halesus** (Cramer), "1779" [1777]
dolichos (Hübner), 1823
juanita (Scudder), 1868
b **h. corcorani** Clench, 1942
form *estesi* Clench, 1942

DOLYMORPHA Holland, 1931

Type: *Thecla jada* Hewitson, "1862" [1867]

409 **jada** (Hewitson), "1862" [1867]

EURISTRYMON Clench, [1961]

Type: *Thecla favonius* Smith, 1797

410 **polingi** (Barnes & Benjamin), 1926
411 **favonius** (Smith), 1797
412 **ontario** (Edwards), "1868–9" (1868)
a **o. ontario** (Edwards), "1868–9" (1868)
b **o. violae** (Stallings & Turner), 1947
c **o. autolycus** (Edwards), "1870–1" (1871)
d **o. ilavia** (Beutenmüller), 1899
mirabelle (Barnes), 1900

HYPOSTRYMON Clench, [1961]
Type: *Thecla critola* Hewitson, 1874
413 **critola** (Hewitson), 1874

PANTHIADES Hübner, "1816" [1819]
Type: *Papilio pelion* Cramer, "1779" [1775]
Parrhasius Hübner, "1816" [1819]
Eupsyche Scudder, 1876
414 **m-album** (Boisduval & Le Conte), [June 1833]
♂ *psyche* (Boisduval & Le Conte) [June 1833]

STRYMON Hübner, 1818 (opinion 541, name 1332)
Type: *Strymon melinus* Hübner, 1818 (opinion 541, name 1602)
Bithys Hübner, 1818 (opinion 541, name 1234)
Bythis Geyer, [1827–31] (opinion 541, name 1236) (*lapsus calami*)
Argus Gerhard (*nec* Bohadsch, 1761, *nec* Scopoli, 1763, *nec* Scopoli, 1777, *nec* Boisduval, 1832), 1850
Callipareus Scudder, 1872
Callicista Grote, 1873
Uranotes Scudder, 1876
415 **martialis** (Herrich-Schäffer), 1864
*416 **acis** (Drury), "1770" [1773]
mars (Fabricius), [1777]
a **a. bartrami** (Comstock & Huntington), 1943
417 **melinus** Hübner, 1818 (opinion 541, name 1602)
a **m. melinus** Hübner, 1818
hyperici (Boisduval & Le Conte), [27 July 1833]
ab. *youngi* Field, 1936
b **m. humuli** (Harris), 1841
ab. *meinersi* Gunder, 1927
c **m. franki** Field, 1938
d **m. pudica** (H. Edwards), 1877

e **m. atrofasciata** McDunnough, 1921
f **m. setonia** McDunnough, 1927
418 **avalona** (Wright), 1905
419 **rufofusca** (Hewitson), "1862" (1877) (*emendatio*)
rufo-fusca (Hewitson), "1862" (1877)
420 **cestri** (Reakirt), "1866" [1867]
421 **yojoa** (Reakirt), "1866" [July 1867]
*422 **columella** (Fabricius), 1793
a **c. istapa** (Reakirt), "1866" [1867]
b **c. modesta** (Maynard), 1873
ocellifera (Grote), 1873
423 **bazochii** (Godart), "1819" [1824]
thius Geyer, 1832
agra Hewitson, 1871
424 **alea** (Godman & Salvin), "1879–1901" [1887]
laceyi (Barnes & McDunnough), 1910
425 **bebrycia** (Hewitson), 1868
buchholzi H. A. Freeman, 1950

ERORA Scudder, 1872

Type: *Thecla laeta* Edwards, 1862
426 **laeta** (Edwards), 1862
♀ *clothilde* (Edwards), "1863–4" (1863)
*427 **quaderna** (Hewitson), 1868
a **q. sanfordi** dos Passos, 1940

ELECTROSTRYMON Clench, [1961]

Type: *Papilio endymion* Fabricius, 1775
*428 **endymion** (Fabricius), 1775
a **e. cyphara** (Hewitson), 1874

Taxonomic Discussion

The following names, arranged in alphabetical order, have been omitted from this revised synonymic catalogue because they are now believed not to occur in the Nearctic region:

?*Lycaena erytalus* Butler, "1869" [1870] (?*lapsus calami* for *Tmolus eurytulus* Hübner, 1819)

Polyommatus hugon Godart, "1819" [1824]

Strymon eurytulus (Butler), "1869" [1870] is a South American species of which *erytalus auctorum* is a misspelling and these names are accordingly omitted from the list.

Strymon daraba (Hewitson), "1861" [April 1867] is also a South American species and dropped from the List.
Strymon pastor Butler & Druce, "1869–76" [1872]
Thecla beroea Hewitson, 1868
Thecla cybira Hewitson, "1862–78" [1874]
Thecla facuna Hewitson "1862" [1877]
Thecla nipona Hewitson, 1877

The following explanations will help answer questions concerning placement of names, especially where the above list deviates from the treatment of Clench, or where more recent information has been incorporated.

HARKENCLENUS

The International Commission on Zoological Nomenclature by opinion 541 suppressed among other names *Chrysophanus* Hübner, 1818, and placed it on the Official Index of Rejected and Invalid Names in Zoology for the purposes of the Law of Priority but not for those of the Law of Homonymy. Consequently, a replacement name is in order. For that purpose *Harkenclenus* has been chosen, being an arbitrary combination of the first syllables of the name of my friend and colleague, Harry Kendon Clench. The new name is masculine.

SATYRIUM

Satyrium edwardsii has from time to time been ascribed to Saunders or Grote & Robinson. It was a manuscript name of Saunders first published by Grote & Robinson (1867) in the synonymy of *S. calanus*. Since that is no longer considered a valid publication (Code, Art. 16 [b] [ii]), the name must be credited to Saunders who validly published it in 1869.

EUMAEUS

Clench removed *Eumaeus* from the Thecliti, and placed it in the Strymoniti.

There are differences of opinion concerning the correct spelling of the name of the type species of this genus. When first published, it was written *minijas*, but when Hübner later proposed this generic name and included this species in it, he wrote the name *minyas*, and that spelling has been generally accepted as a justified emendation. It seems better to adhere to the present practice especially since Minyas was a Greek hero and the letter "j" was not included in the classical Latin alphabet.

HETEROSMAITIA

Thecla spurina Hewitson, "1862" [1867] and *T. zebina* Hewitson, "1862" [1867] were both named from single specimens taken in the

Amazon and Nicaragua respectively. One specimen of each has been reported from southern Texas by Stallings & Turner and H. A. Freeman. According to Clench *in* Ehrlich & Ehrlich ([1961]: 198), "Their true identity remains uncertain." The former according to Clench (*in litt.*) belongs to the genus *Heterosmaitia* Clench, 1964, and it is probable that the latter belongs to the same genus. He is unable to place them with certainty at present.

CALLOPHRYS

Clench *in* Ehrlich & Ehrlich treats *Callophrys viridis* as a species in his key but omits it from the text. It is here included as a valid species. Further studies, on the biology and larval morphology, by G. A. Gorelick (J. Lepid. Soc., in press) have tended to confirm this separation.

ATLIDES

The correct taxonomic standing of *estesi* presents a problem of nomenclature. The name was proposed as "*Atlides halesus corcorani*, form *estesi*, new normal form" (Clench, 1942). From a reading of Clench's paper, it is clear that he intended *estesi* to represent the western population of *halesus*. On the other hand, Gunder had proposed *corcorani* as a transitional form (1934: 131). Transitional forms are generally considered aberrations, but Clench by his action gave this one subspecific standing. Accordingly, these names have been left as they stand in the synonymic list, but the authorship of *corcorani* has been ascribed to Clench, 1942.

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ON THE NATURE AND USE OF THE SUFFIX *-ELLUS, -ELLA, -ELLUM* IN SPECIES-GROUP NAMES

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The use of the suffix *-ellus* (*-ella, -ellum*) to form species-group names, especially in Microlepidoptera in the form of *-ella*, has been common for a long time, but fortunately it now seems to be waning. There is nothing to be gained by adding this suffix to specific names, except a few letters to the length of the name. Of the approximately 950 names cited in Heinrich's revision of the American Phycitinae (1956), for example, more than 500 are formed with this suffix, starting with *Tinea abietella* Denis and Schiffermueller, 1776,[2] *Tinea convolutella* Hübner, 1796, *Tinea decuriella* Hübner, 1796, and *Tinea elutella* Hübner, 1796, and continuing to *Ambesa columbiella* McDunnough, 1935, and *Epischnia vividella* McDunnough 1935. None of the 89 new names proposed by Heinrich in this work are formed in this wise.

Latin grammars deal with *-ellus, -a, -um* as follows:

a) . . . "diminutives (with endings for gender), forming nouns or adjectives, meaning *little* or *tender*: as . . . *puella, asellus, misellus.*" (Allen and Greenough, 1872).

b) "There is a class of derivatives called diminutives, which express smallness: hence also sometimes endearment, contempt, pity, or depreciation. Such are of the

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[2] I am indebted to R. W. Hodges for pointing out that the ending dates back at least to the 10th edition of Linnaeus' Systema Naturae, where the genus *Phalaena* is divided into 7 sections, in some of which the specific names regularly bore characteristic endings: Bombyces, Noctuae, Geometrae (-aria and -ata), Tortrices (-ana), Pyralides (-alis), Tineae (-ella), Alucitae (six species: monodactyla, didactyla, tridactyla, tetradactyla, pentadactyla, hexadactyla). These sections were distinguished in a manner similar to that in which we now designate subgenera, e.g., *Phalaena* (*Tortrix*) *ocellana*, *P.* (*Tinea*) *bella*, *P.* (*Tinea*) *euonymella*. The Linnean sections now correspond roughly to families. The endings were used by later authors in various families. The endings -ana and -alis form adjectives; -aria and -ata are used with both nouns and adjectives; and -dactyla is the second member of compounds, which with the numerical 1st members form adjectives.

same gender as their primitives. They are formed by adding 1. *-ulus, -ula, -ulum* . . .; 2. *-culus, -cula, -culum* . . . Note 2.—A contraction is sometimes formed (especially when the clipt stem of the primitive ends in l, n, or r), and the termination is changed into *-ellus, -ella,* or *-ellum*; . . . *oculus,* an eye, *ocellus,* a dear little eye; *catulus,* a puppy, *catellus,* a little puppy; *populus,* the people, *popellus,* the rabble . . . Note 4.—Adjectives also have diminutives: as *miser, misellus.*" (Chase, 1882).

c) "Diminutives, either nouns or adjectives, are formed from nouns or adjectives with the endings . . . *ellus,* in any or all genders . . . The gender of the primitive word is generally retained in the diminutive. (Examples) *castellum, tabella, libellus, puella, flagellum.*" (Jenks, 1911).

d) "From the stems of other nouns . . . *El-lus, el-la, el-lum,* . . . are used when the stem of the primitive ends in a or o, preceded by l, n, or r: *ocellus* . . ., *fabella* . . . Adjectives from adjectives . . . Note 1.—The endings *ellus* and *illus* also occur as nouns: novellus." (Harkness, 1892).

e) "The diminutive ending *-ellus* is due to phonetic changes: as *agellus* (*ager*); *fabella* (*fabula*) . . . Diminutive adjectives are formed like diminutive nouns, and with a similar variety of meaning: *pulchellus* (from *pulcher*)." (Burton, 1911).

Cooper (1895), in an extended work on word formation in popular Latin, devotes 33 pages (pp. 164–195) to diminutives, pointing out that they lost strictly diminutive meaning at an early date, that such weakening of the meaning continued throughout the history of the language, that in later periods a fondness for compound, 2nd and 3rd degree diminutives became more evident, and that diminutive adjectives were far less numerous than diminutive nouns. He cites many examples.

Stern (1966, p. 289) remarks, in regard to generic names in botany, that " . . . the suffix *-ella* has now come to be regarded, particularly by mycologists, as being simply a name-forming component to be attached to any personal name or any generic name of either Latin or Greek origin, usually without implication of smallness." The same condition is true with regard to generic names in entomology, and at least in the Microlepidoptera the condition has been carried over into species-group names. The following examples, all from Heinrich (1956), will show this.

A) From nouns: abietella (Abies), arizonella (Arizona), bahamasella (Bahamas), bacerella (Baker), bakerella (Baker), cacabella (cacabus), castrella (castrum = Fort [Wingate]), cnabella (Knab), constitutionella (constitution = constitutio), crataegella (Crataegus), exsulella (exsul), fasciella (fascia), gitonella (Greek geitōn), glendella (Glenwood [Springs]), homoeosomella (Homoeosoma), illuviella (illuvies), titillella (titillus).

B) From adjectives: aeneella (aenea), abietivorella (abietivora), albescentella (albescens), albidiorella (albidior), angustellus (angustus), atrella (atra), australella (australis), cinerella (cinerea), glabrella (glabra; better glabella), melanellus (melas, melan-).

C) From ?: cinerella (? noun cinis, ciner-; ? error for cinereella), demotella (? Greek noun dēmotēs); immorella; jocarella; obnupsella; obsipella (? verb obsipo); oporedestella (? Greek nouns opōra + edestēs); plorella (? verb ploro); senesciella (? verb senesco), verecuntella (? adj. verecunda).

With generic names ending in *-ellus, -ella, -ellum,* there is no trouble, since these endings clearly show the gender. But with species-group

names, it is necessary to know whether the name is noun or adjective when it is transferred to a genus of different gender. We cannot simply say that the names are either all nouns or all adjectives. It is not possible to make good Latin words like *pulchella*, *atrella*, or *angustellus*, into anything but adjectives, nor is it possible to make anything but nouns (invariable as to gender) out of such words as *cacabella*, *exsulella*, *castrella*, *bakerella*, *arizonella*, etc. With names that are obviously either nouns or adjectives by original stated derivation, by Latin or Greek dictionaries, by derivation from a generic name, etc., there is a clear choice, but with words such as those cited in category "C" above, no source yields any usable data for the choice between noun and adjective.

As an example of the problems that could be encountered, let us suppose that 7 names recently proposed (Shaffer, 1968) were to be transferred to a genus of different gender. These names are *Anacostia tribulella*, *Arivaca artella*, *A. linella*, *A. poohella*, *Homosassa incudella*, *H. platella*, and *Peoria floridella*. No derivations were given for these names, but personal communication with the author brought out the information that *floridella* was based upon the name of the State of Florida, that *incudella* was based upon the Latin verb *incudo* ("because the male genitalia have a part resembling an anvil"), and that the others are neologisms, or made-up names. None of these names contravenes any of the International Rules of Zoological Nomenclature; they are therefore validly formed and even rather good names from the standpoints of simplicity, shortness, distinctiveness, and ease of pronunciation for most people.

Many zoologists nowadays are simply coining names rather than going through a rather laborious and time-consuming process of looking for something apt and linguistically correct in a language with which they lack familiarity. But that course, too, has its limits and dangers. One might come up with the names *alba* and *leo* by shuffling a set of letter cards, but the fact that those words have been good Latin words for many centuries cannot be controverted. They now belong to all mankind and cannot be said by any one person to mean anything other than what their usage as recorded in lexicons has been all this time.

Therefore, of Shaffer's names, one must be considered an adjective (*artella*, from the Latin adj. *artus*, *-a*, *-um* close, narrow, confined) and 5 others are clearly nouns (*floridella*, from Florida rather than from the Latin adj. *floridus*, *-a*, *-um* flowery; *tribulella*, from Latin noun *tribulus*; *incudella*, from the Latin noun *incūs* anvil, with gender change [the verb *incudo* is from the same root]; *linella*, from the Latin noun *linum* flax, thread, line, rope, with gender change; and *platella*, from either of the Greek nouns *platē* blade, flat part of an object, or *platos* breadth, but not

from the adj. *platys*, which would give *platyella*). This last name could have been formed from the generic name *Platus* Motschulsky, 1844 (Coleoptera), far-fetched of course, but that would also make *platella* a noun.

The remaining name, *poohella*, is rather obviously made-up; at least I can find no classical basis for it, nor does there seem to be a genus-name it could have been based upon. Since it is a neologism and certainly not derived from any Latin or Greek adjective, it is best considered as a noun, the most basic part of language. In order to be an adjective, it would have to have a meaning of adjectival nature. Any word, however, can be used as a noun. Latin adjectives had the capability of usage as nouns, but as species-group names in biological nomenclature what is by nature an adjective can have nothing like Latin sentence structure to show that it is being used as a noun. The names *obsipella* and *plorella* (see above, from Heinrich, 1956), being traceable only to a verbal root, are also best considered as neologistic nouns.

As long as the International Rules and the Latin language are what they are, indication of the derivation of newly formed names is highly to be recommended to save other workers much time and effort that might be used much more profitably. The tracing of such a word as *cacabella* to the obscure Latin word *cacabus*, found in only the most complete lexicons, or the word *incudella* to the noun *incūs*, with its hidden root form *incud-*, is certainly not a very useful occupation.

More concise statements in the International Rules regarding availability and treatment of non-Latin specific names would also do much to obviate growing confusion.

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NEW MICHIGAN BUTTERFLY RECORDS

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Since the death of Sherman Moore in 1956, and the publication of his list of Michigan butterflies (1960), the writer has assumed the task of maintaining a card-file index of all Michigan butterfly records, with the goal of preparing a new annotated list. During this period, considerable collecting has occurred throughout the state, particularly in the Upper Peninsula and on Isle Royale. This period has seen a definite increase in the number of resident lepidopterists and young insect collectors, especially among the 4-H group. Therefore, it seems worthwhile to publish certain new significant records at this time. Hopefully, this addendum may encourage lepidopterists to search diligently in the state for additional species to further the knowledge of the distribution and habits of Michigan's butterfly fauna.

Field trips to Isle Royale by David Bixler, Edward Voss and Ron Willson have added immeasurably to our meager knowledge of the island's butterfly fauna, which incidentally appears to be similar to that of northern Minnesota and northern Ontario. Collecting by Virgil Warczynski of Bay City is responsible for many new county records, particularly in the Saginaw Bay area. Brief collecting forays by John Masters of Minnesota into the western portion of the Upper Peninsula have produced interesting new records; John Newman and the writer have done extensive collecting in the numerous sphagnum-heath bogs in the eastern Upper Peninsula since the publication of Moore's list. Additional Upper Peninsula records were found in the insect collections at Northern Michigan University in Marquette and Michigan Technological University in Houghton.

As a result of these additional records, we can now add over 300 new county records, including 7 new species (noted with an asterisk) to our list. Only those new county records which significantly extend a species' range, or relate to a scarce or extremely local species are treated in this supplement. Also, there is recognition of certain subspecies heretofore omitted by Moore. With the addition of these new state records, our Michigan butterfly fauna now constitutes 147 recognized species. Hopefully, further collecting on Isle Royale, in the Upper Peninsula, and in the southwestern Lower Peninsula should eventually bring the state list to at least 155 species. Knowledge of any new state or county records not previously published from Michigan would be appreciated by the writer.

In presenting the following records, the nomenclature and arrangement

of Klots (1951) has been adopted in order to maintain conformity to Moore's list.

Satyridae

Euptychia mitchellii (French). Branch, Lenawee Counties, June 30, July 11. These two locations were previously unrecorded (McAlpine, Hubbell, Pliske, 1960). Additional data is still needed to delineate its exact range in Michigan, especially the northern limits.

Oeneis macounii (Edwards). Isle Royale, June 27, 1964. A fresh pair was collected by Ron Willson in Section 22, T66N, R34W; other specimens were observed in this section on Greenstone Ridge. The specimens are deposited in the Michigan State University collection at East Lansing. This is the first record of the species from the main island since its discovery on one of Isle Royale's satellite islands by R. N. Rysgaard (Newcomb, 1941). It would indicate that *macounii* is a resident on Isle Royale and should be searched for elsewhere on the island, as well as in suitable habitats in the Upper Peninsula. The butterfly has a tendency to resemble *Limenitis archippus* (Cramer) in flight (Fletcher, 1888), and inhabits open jack pine forests (Masters, Sorensen, Conway, 1967).

Oeneis jutta ascerta Masters & Sorensen. Chippewa, Mackinac Counties, May 29, June 15. Several specimens were collected and observed in black spruce-tamarack bogs (Nielsen, 1965). This recently described subspecies (Masters, Sorensen, 1968) should also occur on Isle Royale and in many acid bogs throughout the Upper Peninsula.

* *Erebia discoidalis* (Kirby). Baraga County, May 31, 1968. One torn male collected by J. H. Masters in a black spruce bog around 5:00 PM. According to correspondence with Masters, *discoidalis* apparently flies early in the morning and late in the afternoon in most northern bogs, a habit that could account for its scarcity to date. This alpine should occur in many bogs across the Upper Peninsula, as it has been previously collected in Minnesota (Huber, 1965) and Wisconsin (Elder, 1961). The Michigan specimen has been deposited in the MSU collection.

Nymphalidae

* *Boloria eunomia dawsoni* (Barnes & McDunnough). Chippewa, Mackinac Counties, June 13–23. The writer has taken additional specimens and located two new colonies in Chippewa County since its discovery (Nielsen, 1965).

* *Boloria freija* (Thunberg). Chippewa, Ontonagon Counties, May 27, 29. The first record was that of a worn male collected by John Newman in Section 9, T49N, R7W in 1965, on a sandy ridge extending across the huge

bog located about seven miles northwest of Paradise (Nielsen, 1965). More recently, it was taken by John Masters in the eastern edge of the Porcupine Mountains State Park.

Boloria frigga (Thunberg). Schoolcraft County, May 30–June 1. Additional specimens have been collected which indicate that the species may prefer a wet, sedgy bog habitat, with willow and dwarf birch, to the true sphagnum-heath bog previously reported (Hubbell, 1957). The writer has collected it in a habitat similar to that reported by Brown (1954) for *frigga sagata* (Barnes & Benjamin) in the Rocky Mountains of Colorado.

* *Polygonia zephyrus* (Edwards). Schoolcraft County, May 29, 1960. One torn male of this western species was collected in an acid bog by the writer (Section 14, T42N, R16W). The specimen was determined by Cyril F. dos Passos and is now in the writer's collection. It would appear this record represents a stray specimen which probably overwintered as suggested by its condition. Undoubtedly, bait could be used to attract additional material, including other scarce boreal species as *P. gracilis* (Grote & Robinson) and *satyrus marsyas* (Edwards).

Anaea andria Scudder. Van Buren County, July 17. This record represents the second location in the state. One specimen was collected by William Bouton at Breedsville. Collectors should look for it in other southern counties, especially at bait.

LYCAENIDAE

* *Strymon m-album* (Boisduval & LeConte). Muskegon County, August 12, 1964. One fresh male, Michigan's first, was collected by John Taggart in Section 13, T11N, R18W, along a sandy road adjacent to scrub oak. The specimen is in the writer's collection. This hairstreak may occasionally occur in our southern scrub oak locations; although it is doubtful that it breeds in the state. According to Clench (1961), the species is triple-brooded in Pennsylvania.

Strymon melinus humuli (Harris). Baraga, Chippewa Counties, May 17, June 21. These are the first records of this hairstreak collected from the Upper Peninsula and they constitute a substantial northern extension. Two worn specimens were taken by the writer near Strongs in an open jack pine area, flying with *Incisalia niphon clarki* Freeman and *Hesperia sassacus* Harris.

Incisalia henrici (Grote & Robinson). Schoolcraft County, June 1. This is the first capture of this elfin in the Upper Peninsula. John Newman collected one fresh specimen along a sandy trail separating a jack pine ridge

and an acid bog; *Vaccinium* sp., one of its known foodplants (Klots, 1951), was abundant in the area.

Incisalia eryphon (Boisduval). Chippewa, Luce, Marquette Counties, May 16–22. The determination of these specimens has been confirmed by Harry Clench (Nielsen, 1966) as representing the western pine elfin. The Mackinac County specimens, referred to by Moore (1960), have since been examined by the writer and were found to represent *eryphon* and not *niphon clarki* as determined by Klots. There is good reason to believe that *eryphon* will be found in pine areas throughout the Upper Peninsula, and that it has previously been overlooked or confused with *niphon clarki.*

Papilionidae

Papilio glaucus canadensis Rothschild & Jordan. Keweenaw County, June 26. Five specimens taken by Ron Hodges at Copper Harbor were determined by Dr. Lincoln P. Brower. This is the first recognition of this subspecies from Michigan; Moore (1960) did not distinguish this from the typical form. No doubt the populations on Isle Royale and throughout the Upper Peninsula and extending south into the Lower Peninsula represents *canadensis.* Specimens collected from Otsego County are indistinguishable from those taken farther north. Further collections of long series should be made to determine the southern limits of *canadensis.*

Pieridae

* *Euchloe ausonides* Lucas. Isle Royale, June 17–29. The species was first collected by Ron Willson in 1964 near Rock Harbor Lodge at the northeastern end of the island. Additional specimens were taken on Mt. Ojibway by David Bixler, and again at Rock Harbor by Ed Voss. Correspondence from Voss indicated that *ausonides* was associated with *Arabis.* Willson's specimen was determined by Dr. A. B. Klots, but was undeterminable as to subspecies. The species has also been collected in northern Minnesota and in the vicinity of Port Arthur, Ontario.

Pieris virginiensis Edwards. Arenac, Otsego Counties, May 5, 26. Several specimens were collected by Virgil Warczynski in hardwoods, thus extending the known range of this pierid to the southeast. Collectors should look for this butterfly in beech-hard maple woodlots in early spring before full leaf development.

Hesperiidae

Pyrgus centaureae wyandot (Edwards). Montcalm County, May 8, 18. The writer has taken this skipper feeding on blueberry blossoms in scrub oak

openings in Section 7, T12N, R10W. This represents the most southern collection site in the state.

Erynnis baptisiae (Forbes). Monroe County, June 5. This skipper was collected by the writer in Section 24, T7S, R6E, in close proximity to wild indigo in scrub oak opening; subsequently, adults were reared from eggs and larvae found on wild indigo plants in this same location. The species is easily confused with our other *Erynnis* species.

Oarisma powesheik (Parker). Kent County, July 4, 13. Several specimens have been collected in recent years by Wilbur McAlpine, V. Warczynski and the writer along the marsh edge of Button and Lamberton Lakes in the north section of Grand Rapids. Somehow, this small and restricted colony has continued to flourish since first reported by Wolcott (1893) despite the suburban encroachment. The writer found the species to be rather fond of black-eyed susan flowers growing near the marsh perimeter. Companion species taken in this habitat included *Calephelis muticum* McAlpine and *Lycaena dorcas* Kirby. It would appear this species can be easily overlooked in this type of habitat.

Adopaea lineola (Ochsenheimer). Cheboygan, Crawford, Houghton, Oscoda, Otsego, Roscommon Counties, June 19–July 22. Several specimens were collected by the writer in the northern Lower Peninsula during the 1960–67 period, and by Ted Ellis, Jr. in Houghton County; these represent significant northern extensions in range for this skipper. Undoubtedly, this skipper will spread to all counties of the state within the next several years. The writer recently collected a long series in two northern Ontario locations (Nielsen, 1966), indicating that the European Skipper is still extending its range in North America.

* *Lerodea eufala* (Edwards). Ontonagon County, August 25, 1959. One torn female was collected by the late Dr. R. R. Dreisbach. Determination of this skipper was confirmed by Dr. A. W. Lindsey; the specimen is in the writer's collection. The skipper may be extending its range northward into the western end of the Upper Peninsula and should be searched for in upland grassy areas.

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HEAD MEASUREMENTS AND WEIGHTS OF THE BEAN LEAF ROLLER, *URBANUS PROTEUS* (HESPERIIDAE)[1]

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The bean leaf roller, *Urbanus proteus* (Linn.), is common on beans and other legumes in Florida during the fall of the year. Head widths and weights of newly molted larvae were determined to learn if larval instars could be accurately distinguished when making field observations.

Larvae were reared on Harvester variety snap bean leaves held in an insect rearing room with the temperature about 85°F. Larvae were kept individually on bean leaflets in round plastic dishes 2 cm deep by 10 cm in diameter with moistened filter paper to maintain leaf turgidity. Fresh leaves were supplied after each molt. Eggs were measured within five hours after oviposition and larval head widths were recorded soon after molting when the head became black. Pupal heads were measured two

[1] Florida Agricultural Experiment Stations Journal Series No. 3241.

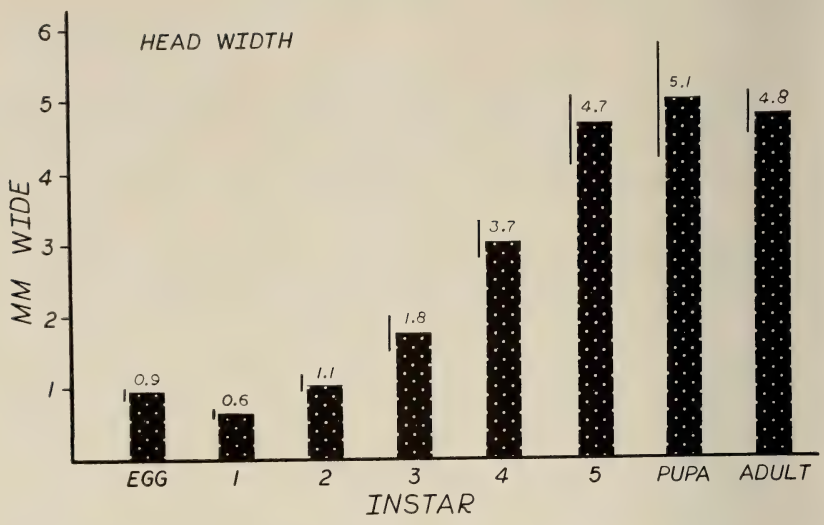


Fig. 1. Comparison of egg and head widths of the bean leaf roller, *Urbanus proteus* (Linn.). Bars and numbers represent means of 50 or more individuals and the lines connect the low and high measurement for each life stage.

days after pupation. All measurements were made on living specimens except for adults, which were killed in a cyanide jar following emergence and measured within one hour after death. Head measurements were made using a dissecting microscope with an ocular micrometer.

Data on the means and ranges of head widths (Fig. 1) demonstrate distinct differences between instars with none of the extreme measurements overlapping from instar to instar. The validity of field determination of instars based on head size is substantiated by these data. The results of these measurements agree with those reported by Quaintance (1898). His measurements, made on preserved specimens, were as follows: eggs 0.966 mm, 1st instar 0.566 mm, 2nd instar 0.866 mm, 3rd instar 2 mm, 4th instar 3 mm, and 5th instar 4.5 mm. Quaintance did not report the extremes or variation within each stage.

Heads of newly eclosed larvae filled approximately ⅔ of the egg interior. The 5th instar, pupal and adult head widths were similar (Fig. 1). When observing the changes during these stages it appeared that pupal heads would be wider than 5th instar larvae by a larger amount than was measured because the 5th instar head capsules split during pupation. The adult emerges from the pupal case without splitting the head covering, therefore its head cannot be wider than the pupal head. The extreme mea-

TABLE 1. Milligrams weight of eight life stages of the bean leaf roller, *Urbanus proteus* (Linn.) taken at the beginning of each stage.

	Egg[a]	1st[a]	2nd	3rd	4th	5th	Pupa	Adult[b]
Low individual	—	—	1	5	29	153	367	100
Mean	0.46	0.41	2.25	11.18	38.59	215.16	407.71	177.60
High individual	—	—	3.5	14	47	265	610	352
Weight change ratio[c]	—	0.9	5.5	5.0	3.5	5.5	1.9	0.4
No. of individuals weighed	170	120	126	117	96	90	85	25

[a] Weighed in groups of 10 per weighing because the balance used was only sensitive to tenths of a mg.

[b] Adults were killed with cyanide and weighed within a few minutes after emergence from the pupa. All other weights were made of living individuals.

[c] The figures are derived by dividing the weight of the indicated stage by the weight of the previous stage.

surements for the adult were much closer than they were for the 5th instar or pupa.

Comparing head measurements by dividing the head width of one instar into that of the preceding instar, ratios of .55, .61, .49, .79 and a mean of .61 were found. Dyar (1890) found ratios of .58 to .73 for 14 species having five larval stages, and the bean leaf roller falls within his range. A lower numerical ratio was expected in an insect with a large head such as a Hesperiidae, but this was not apparent with the bean leaf roller.

Dyar (1890) mentions the smaller size of head capsules from larvae which died after molting. Several bean leaf roller larvae which died were compared to the average of each instar. The first four instars which died had similar measurements to live specimens, but the dead 5th instar heads were much smaller than the average, and two which had not grown during the 4th instar had heads smaller than the previous instar. Measurements of live and preserved head capsules were very similar, even for 5th instar heads which had split during pupation.

In conjunction with head measurements larvae were weighed to record the weight increase from molt to molt. These weights were made just after molting rather than before molting to allow for uniform weighing. Weights just before molting would have been nearly impossible to make due to the difficulty of knowing when the larvae had completed their feeding. By weighing soon after molting, uniform weights were made for individuals of each instar and feeding or molting was not interrupted. Larvae had not begun to feed after molting when they were weighed.

The weights are given in Table 1 for the eight life stages. All weights

TABLE 2. Conversion of eaten leaf weight to bean leaf roller (BLR), *Urbanus proteus* (Linn.), weight for five life stages.

	Egg	1	2	3	4	5	Pupae
Leaf eaten (mg)	—	11	28	110	567	3343	—
BLR weight (mg)	0.46	0.41	2.3	11.2	38.6	215.2	407.7
BLR gain (mg)[1]	—	1.9	8.9	27.2	186.6	192.5	—
Conversion ratio[2]	—	0.17	0.32	0.24	0.33	0.06	—

[1] This figure derived by subtracting weight of one instar from the weight of next instar. The weight lost during molting is not included because weights were made after molting but before feeding resumed.

[2] Conversion ratio $= \frac{\text{mg BLR gain}}{\text{mg Leaf eaten}}$.

are of live specimens, except for adults, which were killed just before weighing. The ratio of gain was largest from 1st to 2nd and 4th to 5th instar and smallest from 5th instar to pupa. The 5th instar gained considerable weight, but lost much of the gain at pupation after which the weights were taken. The small loss of weight from egg to newly eclosed larva, only 10%, was a surprise, since newly eclosed larvae do not eat any of the egg shell and loss of fluids during eclosion was noted.

The conversion ratio of leaf weight to body weight of each larva was calculated by dividing the weight of leaf tissue eaten by the weight increase during each instar (Table 2). The efficiency of the 1st and 5th instar to convert leaf weight into body weight was low, whereas the efficiency of the other 3 instars was similar. The figure of 0.3 is close to the conversion ratios reported by Taylor and Bardner (1968) for the diamond back moth on a dry weight basis. The low conversion ratio for the 1st instar was unexpected since larval weight increased 5.5 times over the newly hatched larvae. After 5th instar feeding the transformation into the pupa results in considerable weight loss as indicated by the 0.06 figure in Table 1.

Przibram and Megusar (1912) concluded that the weight of each instar should double that of the preceding instar and Bodenheimer (1932) added latent divisions for holometabolic insects. Instar weights obtained for the bean leaf roller agree closely with those reported by Przibram and Megusar when the latent division calculations of Bodenheimer are used.

CONCLUSIONS

Measurements of bean leaf roller heads demonstrated that larval instars can be accurately distinguished. The head widths did not overlap from one instar to the next and the standard deviation was 0.4 mm for the 5th

instar and pupae, 0.1 for adults and less than 0.1 for the other life stages. Head capsules which had been shed during molting were similar in width to live specimens.

Larval weight increased approximately 5 fold during each of the 2nd, 3rd, and 4th instar periods. The 5th instar increased in size and weight but lost much of the increase during pupation. Adults weighed 0.4 times as much as did the pupae, and 1st instar larvae averaged 0.9 times as much as the eggs. A greater proportion of weight was lost during the transformation from 5th instar to adult than during eclosion.

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WHAT'S YOUR COLLECTION WORTH

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In discussing the value of a collection of Lepidoptera we must first define "value" by some criterion. We can first consider its monetary value: the amount spent on materials, storage equipment, library, and the procurement of specimens; and also the fair market value if it were to be sold to a dealer, private collector, or institution. Next, there is the sentimental value to the collector. Most collectors probably value their collections far beyond a fair market value simply because of all the hours of sweating, searching, panting, itching, squinting, cursing, and joyful whooping that accompany the perfect avocation. Finally, we shall discuss the scientific value: what information useful in taxonomic and faunistic research is intrinsic in the collection? The scientific value can sometimes be related to monetary value; but, too often, institutional collections cannot afford to purchase highly desirable collections, and must rely upon donated material for research purposes.

The monetary value of a collection depends upon several factors, most important of which is the quality of the material. Large collections, containing showy and unusual exotic species, should command a good price among the few dealers who buy and sell Lepidoptera. Material from poorly-collected areas, unusual forms, type specimens, and unusual, well-labeled perfect butterflies and moths will be in much more demand than a small local collection of common species. There can be no fixed price for specimens because of the variables of quality, rarity, and attractiveness as well as supply and demand; but one can compare his material with that offered at various prices by dealers to get some estimate of value, whether for pricing his collection, or for evaluation for insurance purposes. Likewise, books and equipment can be evaluated by checking dealer price lists.

One can realize monetary benefits by donating his collection to a major museum or university collection. He can include the value of donated material in the "miscellaneous contributions" section of Itemized Deductions on his income tax returns. In checking with the Internal Revenue Service, I found that IRS normally accepts the value placed on such donations by an official of the recipient institution who will prepare a statement of value for the donor. From experience and also in checking with an official of one of the nation's largest museums, I know that $.15 per specimen is an acceptable average value for insects. I would think that one could justify a slightly higher amount for spread Lepidoptera, because of the time put into setting. Also, rare or otherwise extraordinary specimens can be given much higher individual evaluations.

With respect to sentimental value, one cannot place a price tag on the aesthetic enjoyment, friendships, and personal satisfaction of building a fine collection. This intangible value is extended to others when they see your specimens, hear you give a talk, or become stimulated to begin or recommence collecting themselves. Although many collectors are satisfied to keep their collections to themselves, I feel certain that those who share their knowledge and experience reap much greater rewards. The pleasure of excited responses from the uninitiated as well as fervent discussion with fellow aficianados is its own reward.

The scientific value of a collection depends first upon the completeness and accuracy of the data on pin labels or papers. Again, the rarity of species, localities represented, and amount of type material are factors important in determining what potential information the collection holds. Condition of specimens is important, too; but it is not nearly as important to the scientist as the dependability of the data furnished by the collector.

Unfortunately, there are many collectors who do not know that a speci-

men without locality and other collection data is worthless to the researcher. Others are careless and get dates and localities confused, or deliberately mislabel specimens to enhance their prestige or line their pockets. The notorious Chokoloskee, Florida, material is a good example of the latter. Although some collectors will always be content to merely place showy specimens in Riker mounts for their walls, I feel most would prefer to prepare a collection that is scientifically as well as aesthetically valuable. And the knowledge that scientific usefulness will also enhance monetary value should act as an additional incentive to prepare accurate labels and keep a field notebook.

Even small local collections can have significant value to science when properly prepared. In many states faunistic knowledge is extremely limited. With more and more land coming under the bulldozer, it is important that as much faunistic work on Lepidoptera as well as other biota be completed as soon as possible. Since professional biologists often have little time for collecting, the role of the amateur in contributing information for taxonomic and faunistic studies is increasingly important.

Sadly enough, many fine collections are lost to science because the collector failed to donate his collection while alive, or arrange for its proper disposal in his will. One important North Carolina collection faded away in display cases in the hallway of a state building; others end up nourishing dermestids in high school labs or family attics. In order to prevent such a loss of your collection, I offer these guidelines:

1. *Keep your collection in good order.* This includes proper labeling (avoiding "coding" of specimens, and poor quality paper and ink), and storage in air-tight, regularly-fumigated containers away from excessive light and moisture.

2. *Donate your collection while you are alive.* If you are no longer actively working on your collection, give it to an institution (or actually incorporate it in person) so that accession will be most efficiently effected. In so doing, you may reap a tax benefit, recover storage equipment to sell or give to a promising beginner, and feel secure that your specimens are in responsible hands of your own choosing.

3. *Spell it out in your will.* If you do not donate your collection now, be sure that you have provided for it according to the laws of your state. Explicit additional directions can be left in writing to aid the recipient in understanding any confusing aspect of the collection; or, better still, arrangements can be discussed with the recipient in advance.

4. *Choose an appropriate recipient.* Although you may prefer to give your collection to a colleague, it is usually better to donate or bequeath it to a large museum or university collection where proper care and use of

your material are assured. Beware of institutions where "perpetual care" is uncertain.

There are certainly other helpful ideas to aid you in evaluating and utilizing your collection for more than the mere pleasure it gives you in making it. With foresight, careful planning, and proper care you can be assured that your collection will be studied and enjoyed long into the future, and that you have made a real contribution to our growing knowledge of Lepidoptera.

THE IMMATURE STAGES OF *SCOPULA ANCELLATA* (HULST) (GEOMETRIDAE)

W. C. McGUFFIN

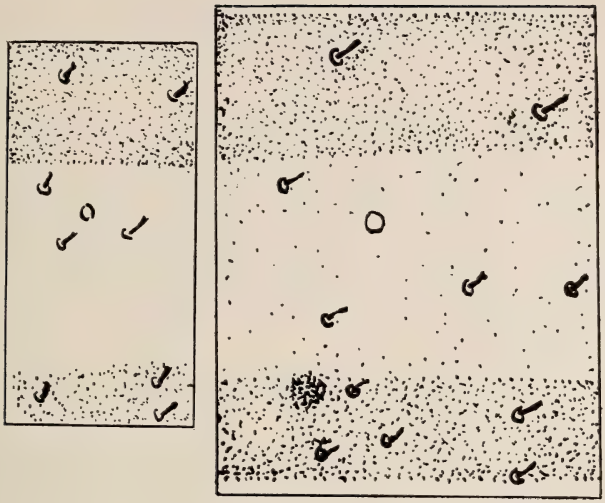
Forestry Branch, Canada Department of Fisheries and Forestry, Ottawa, Ontario

While working in the Hedley, British Columbia, area in 1967 I collected several adults of *Scopula ancellata* (Hulst) between July 4 and 12. One of these moths laid 112 eggs. As in other species of *Scopula* (McGuffin 1967) the eggs were laid loosely on the floor of the cage or on pieces of dead grass scattered over the floor of the cage. After eight to 10 days the eggs hatched. The first-instar larvae accepted the foliage of white sweet clover, *Melilotus alba* Desr., Chinese elm, *Ulmus pumila* L., and mountain alder, *Alnus tenuifolia* Nutt. Some of the larvae completed development and pupated in about 40 days. From these pupae, six males and two females emerged September 4 to 17, 1967. The great majority of the larvae however, ceased feeding towards the end of the summer. They were buried in glass containers in the soil on September 30, 1967, and dug up on May 12, 1968. Most of the larvae were dead when examined but a few survived. From these a male and a female emerged June 27, 1968.

DESCRIPTIONS OF IMMATURE STAGES

Egg: Longer than wide, with longitudinal ridges and cross striae. Whitish to light brown when first laid, later with red spots. Length, 0.75–0.80 mm; width, 0.34–0.50 mm.

Larva: **First instar.** Length, 3–4 mm; width, 0.2–0.4 mm. Head: Width, 0.28–0.34 mm; brown. At higher magnification (100×) herring-bone pattern evident on parietal lobes. Body light brown, with dark-brown dorsum and venter (Fig. 1). **Second instar.** Length, 5–8 mm; width, 0.4–0.5 mm. Head: Width, 0.36–0.40 mm; light brown, with fine brown markings in herring-bone pattern on lobes. Body light brown, with dark brown dorsum and venter; small brown patch on A1–A5, inclusive, between setae L2 and SV2. **Third instar.** Length 9–10 mm; width, 0.5 mm. Head: Width, 0.48–0.50 mm. Colour pattern of head and body as in second



Figs. 1 and 2. *Scopula ancellata* (Hulst), setal and colour patterns on second abdominal segment of larva. 1, First instar; 2, mature larva.

instar. **Fourth instar.** Length, 12–18 mm; width, 0.7–1.0 mm. Head: Width, 0.65–0.67 mm. Light grey with brown markings in herring-bone pattern on lobes. Body light grey, with wide dark-grey middorsal stripe and narrow addorsal line on thorax and posterior abdominal segments; these two lines almost fused on anterior abdominal segments to form a solid stripe. Midventral line light grey; subventral region grey. A small brown spot, anterior to seta L3 and between setae L2 and SV2, on each anterior abdominal segment. Thoracic legs light grey; prolegs grey, with a light-grey line along each. Plates concolorous. **Fifth instar.** Length, 18–22 mm; width, 0.8–1.0 mm. Head: Width, 0.84 mm. Colour pattern of head and body much as in fourth instar. **Sixth instar.** Length, 19–25 mm; width, about 1.0–1.5 mm. Head: Width, 1.34–1.50 mm. Light brown with brown herring-bone pattern on lobes. Antennae light brown. Body light brown with brown middorsal line. Brown spot between setae L2 and SV2 on A1–A5, inclusive. Venter brown, with light brown midventral line (Fig. 2). Legs, prolegs, and plates concolorous.

Pupa: Brown, fusiform, much as in *Scopula inductata* (Guenée) (McGuffin 1967, Fig. 84e, f).

Remarks

The mature larva of S. *ancellata* can be separated from the larvae of other species of *Scopula* on the basis of the brown spot on the anterior abdominal segments between setae L2 and SV2. Apparently no other species of *Scopula* has this spot.

Literature Cited

McGuffin, W. C. 1967. Guide to the Geometridae of Canada (Lepidoptera). Part 1. Subfamily Sterrhinae. Mem. Ent. Soc. Can. No. 50.

GENERIC NOTES ON TWO HAIRSTREAKS NEW TO THE UNITED STATES (LYCAENIDAE)

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In the paper that follows this one, Mr. Roy O. Kendall reports the capture in Texas of three species of hairstreaks that are well known in Mexico, but had not previously been found in the United States. One of these is in good taxonomic order, but the other two require revision to bring their nomenclature up to date.

Ocaria Clench, **new genus**

Type species: *Thecla ocrisia* Hewitson 1868

Antennae composed of about 30 segments, of which the last 13 comprise the club; four terminal segments scaleless; an additional seven ventrally scaleless; longest shaft segment about 3.8 times as long as average club segment, the shaft slender, each segment white-ringed proximally. Eyes with dense, moderately long hair. Frons with erect scales and long, loose, erect bristles. Palpi with terminal segment long and slender, smoothly scaled; next proximal segment with erect ventral scales but no bristles.

Forewing with M_2 from near middle of cell-end, $(M_1\text{-}M_2)/(M_1\text{-}M_3) = 0.47$; a large scent pad filling the end of the cell from one side to the other, and extending basad to near the origin of Cu_2; scent pad composed of densely packed ochreous scales with a few fuscous scales intermixed; pad itself rimmed with densely packed modified scales of ground color. Hindwing with no tornal cleft, virtually no tornal lobe, and with only a short tail at Cu_2, shorter than apical width of interspace $Cu_1\text{-}Cu_2$.

Male genitalia (Fig. 1). Uncus lobes low, rounded, laterally narrow and quadrate, separated by a broad low median notch; falces broadly curved, practically without an "elbow," apically constricted but not hooked; vinculum with slight shoulder, but no shoulder process; posterior dorsal vinculum with thickened margin; anterior vinculum angularly produced midlaterally, associated with moderate coremata (scales about ⅓ as long as penis); saccus subquadrate, barely longer than width at middle; valvae loosely contiguous to tips, of normal length, broad to beyond middle, then abruptly narrow, but not tapered; penis about 2.5 times as long as valvae ($1.9 \times$ valvae + saccus), with tip slightly upturned, armed ventrally with a terminal triangular keel, proximally dentate, distally smooth; two apical multidentate cornuti, one subapical cornutus, not dentate but bluntly acuminate at its distal end.

Remarks. Ocaria is one of the few neotropical relatives so far discovered of the holarctic *Satyrium*. It differs from all others in the *Satyrium* series (*Chlorostrymon* Clench; *Phaeostrymon* Clench; *Satyrium* Scudder; *Chrysophanus* Scudder) in the projecting triangular shape of the ventral distal keel on the penis, in the presence of an anterior process on the vinculum for attachment of the coremata, and in the doubled distal (dentate) cornutus. The thickened posterior margin of the vinculum is found only in *Chlorostrymon* of the other known genera; in all the rest this thickening appears more or less internally as the vinculum strut.

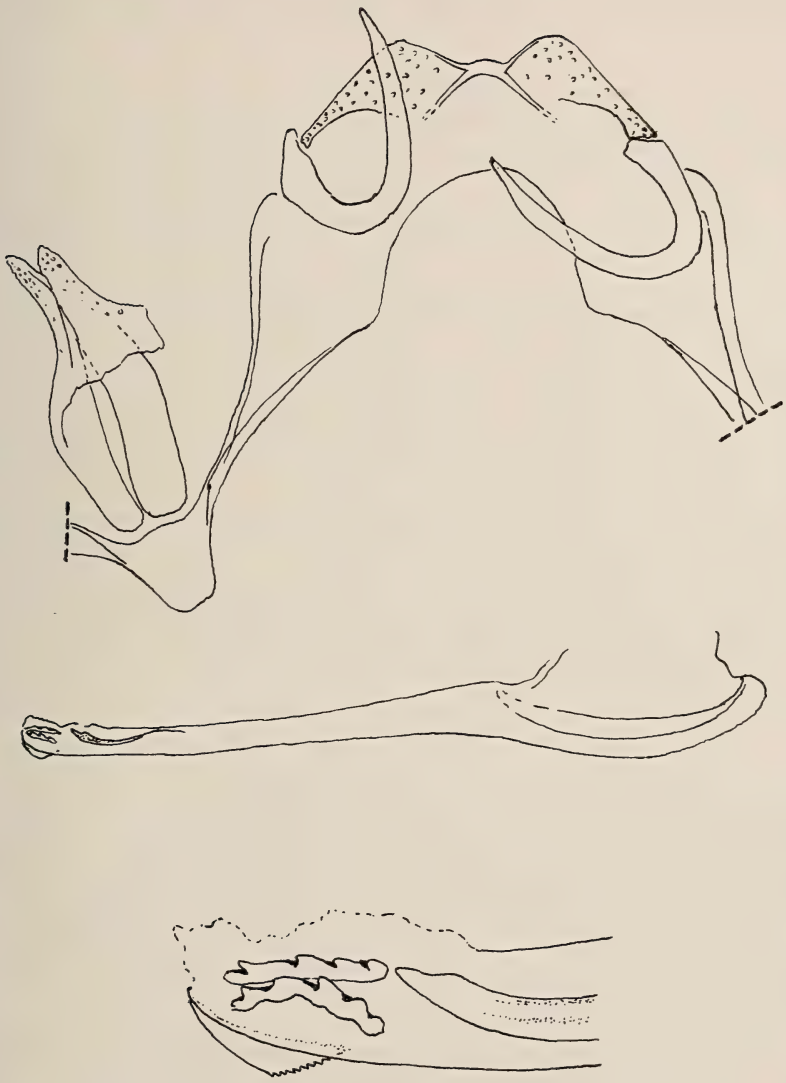


Fig. 1. *Ocaria ocrisia* Hewitson, ♂ genitalia. Top figure, genital capsule cut through the right vinculum and "unrolled," with uncus and falces at top; left vinculum, saccus and valvae to left. Middle figure, penis to same scale. Bottom figure, apical end of penis (enlarged to show cornuti and the serrate ventral keel). Specimen from near Gomez Farías, 300 m, southern Tamaulipas, Mexico, 9.I. 1966 (*leg.* H. Clench and L. D. Miller, CM-CUA Exp.), Slide no. C-1149, CM.

Ocaria ocrisia is the only member of the genus which I have examined. One or two additional species (South American) may ultimately be found to belong here as well.

Thereus Hübner

Thereus Hübner [1819], Verz. bek. Schmett. (5): 79 (type species, by monotypy: *Papilio lausus* Cramer [1779]).
Genus ? (*new genus*): Clench 1961, *in* Ehrlich & Ehrlich, *How to Know the Butterflies*: 198.
Heterosmaitia Clench 1964, J. Res. Lepid. 2 ("1963"): 254 (type species, by original designation: *Thecla bourkei* Kaye 1924). NEW (SUBJECTIVE) SYNONYMY.

Until recently, no specimen of the species *lausus* Cramer was available to me for study. Its peculiar pattern resembled no *Heterosmaitia* I had seen and it never even occurred to me that it might belong here. I have now examined a specimen, and its genitalia indicate beyond any doubt that it is congeneric despite its peculiar appearance. Because it is the type species of the Hübnerian genus *Thereus*, which has some 15 decades priority over *Heterosmaitia*, the latter name must fall.

Two species, *neora* Godman & Salvin and *palegon* Cramer, have been found, just as surprisingly, congeneric as well, although fortunately neither is involved in any serious problem of generic nomenclature. The former heretofore was placed in the genus *Atlides* Hübner (with which its underside pattern agrees rather well). The two species bear no pattern resemblance to each other whatever, nor do they resemble *lausus*, nor are they at all similar to any of the other members of the genus so far as now known.

In contrast to these species (*neora*, *palegon*, *lausus*), which are so highly dissimilar, other species (*thoana*, *guadala*, *brescia*, *bourkei*) are so similar to one another that they pose major problems of identification. These "cryptic" species are so extremely similar, particularly in their underside patterns, that they possibly form some sort of mimetic association.

In my earlier paper (1964) I divided the genus into two groups. These groups (characterized in that paper), with the species now known to belong to them, are:

1. *oppia* group. Includes *oppia* Godman & Salvin (Middle America) and *neora* Godman & Salvin (Middle America). Besides being very different in pattern, these two differ structurally enough to warrant eventually being placed in two subgroups.

2. *bourkei* group. The subgroups I proposed (1964) must now be revised to accommodate the new additions.

Subgroup A. Male scent pad simple; corematal process broad and triangular; larger cornutus with many teeth; valvae divergent from mid-

dle and of normal length (reaching about to falcal shoulder). Includes *bourkei* Kaye (Jamaica), *guadala* Schaus (Middle America), *brescia* Hewitson (neotropical, widespread), *palegon* Cramer (neotropical, widespread).

Subgroup B. Male scent pad duplex, but without a rim of modified scales; corematal process broad, parallel-sided, long and apically rounded; larger cornutus with many teeth; valvae of normal length, contiguous to near tips. Includes *thoana* Hewitson (Middle America) and possibly several South American species of similar appearance (*stagira* Hewitson; *erenea* Hewitson).

Subgroup C. Male scent pad duplex and rimmed with enlarged, densely packed scales of ground color; corematal process elongate, tapering-triangular; larger cornutus without apical teeth; valvae extremely elongate-attenuate (similar to those of the genus *Allosmaitia* Clench 1964), reaching about to the tip of the falx, loosely contiguous to tips. Includes *lausus* Cramer (neotropical, widespread).

THREE HAIRSTREAKS (LYCAENIDAE) NEW TO TEXAS AND THE UNITED STATES

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Hurricane "Beulah" struck the mainland of extreme south Texas near Brownsville, 20 September 1967. Thousands of acres in the Lower Rio Grande Valley were completely inundated. Santa Ana National Wildlife Refuge located on the Rio Grande near Alamo, Hidalgo County, Texas, was such an area. This is a favorite collecting spot for lepidopterists and a number expressed concern over the insect life there. With so much water, some collectors thought the insect life would be largely destroyed. When collecting trips could be resumed, I found that little if any damage to the insect populations had been done. On the contrary, in many ways improvements had occurred.

Extensive flooding had germinated seeds of native plants which had been dormant for a long time. A profusion of vegetation was produced the following year. "Beulah" also evidently distributed insects over wide areas, extending normal ranges for many species. This is evident by new records in 1968 for Hesperiidae, Lycaenidae, and Heliconiinae

from Texas and the United States. Only the Lycaenidae are treated in this paper.

It will be interesting to see if these species become established in the Refuge, and if so for what period of time. A number of species found in Texas appear to be periodic residents when conditions are favorable.

Ocaria ocrisia Hewitson, 1868

Thecla ocrisia Hewitson 1868, Descr. New Species Lycaenidae, p. 5 (TL: Ecuador); *ibid.* 1869, Ill. D. Lep. Lycaenidae, p. 123, pl. 48 figs. 235, 236; Godman & Salvin 1887, Biol. C.-Amer., Lep. Rhop. 2: 49, pl. 54 figs. 5, 6; *ibid.* 1901, *op. cit.* (suppl.), p. 718; Draudt 1920, *in* Seitz, Gross-schmett. Erde 5, p. 775, pl. 152 h; Hoffmann 1941, An. Inst. Biol. (Mexico) 11: 711; Comstock & Huntington 1962, J. New York Ent. Soc. 70: 39 (Note: original description erroneously credited to "Specimen of a Catalogue of Lycaenidae in the British Museum").
Ocaria ocrisia: Clench 1970, J. Lepid. Soc. 24: 56, 58.

One ♀, very worn, Santa Ana Nat. Wildlife Refuge, nr. Alamo, Hidalgo Co., Texas, 11–xi–1968 (*leg.* R.O.K.).

In Mexico this is a widespread but uncommon and rather local species occurring mostly in mesic to moist forest. It has been found (Hoffman, *l.c.*, and Carnegie Museum) as far north as southern Tamaulipas and Jalisco.

Thereus palegon Stoll, 1780

Papilio palegon Stoll 1780, Pap. Exot. 3: 159, pl. 282 figs. C, D (TL: "Sierra Leona, sur la Côte d'or de l'Afrique," which is erroneous; the type was probably taken in Surinam); Comstock & Huntington 1962, J. New York Ent. Soc. 70: 100.
Papilio myrtillus Stoll 1784, Pap. Exot. 4: 178, pl. 380 figs. B, C (TL: "Suriname"); Comstock & Huntington 1961, J. New York Ent. Soc. 69: 176.
[Name has sometimes been misspelled *mytillus*.]
Thecla juicha Reakirt 1866, Proc. Acad. Nat. Sci. Philadelphia: 338 (TL: near Vera Cruz, Mexico); Comstock & Huntington 1961, J. New York Ent. Soc. 69: 56. [Name has sometimes been misspelled *juica*.]
Thecla palegon: Hewitson [1867], Ill. D. Lep. Lycaenidae, P. 86; Godman & Salvin 1887, Biol. C.-Amer., Lep. Rhop. 2: 37; *ibid.* 1901, *op. cit.* (suppl.), p. 716; Draudt 1919, *in* Seitz, Gross-schmett. Erde 5: 761, pl. 150 d, e; Hoffmann 1941, An. Inst. Biol. (Mexico) 11: 707.
Thereus palegon: Clench 1970, J. Lepid. Soc. 24: 58, 59.

One ♂, condition fairly good, Santa Ana Nat. Wildlife Refuge, nr. Alamo, Hidalgo Co., Texas, 9–xi–1968 (*leg.* R.O.K.).

A common and widespread species of the New World tropics, known in Mexico (Hoffmann, *l.c.*, and in Carnegie Museum) as far north as southern Tamaulipas. It is found chiefly in tropical and subtropical forest, including nearby open areas.

Allosmaitia pion Godman & Salvin, 1887

Thecla pion Godman & Salvin 1887, Biol. C.-Amer., Lep. Rhop. 2: 56, pl. 54 figs. 28–30 (TL: Dueñas (Polochic Valley) and Calderas, both in Guatemala, were listed by

the authors; Comstock & Huntington (1962, *infra*) restricted it to the former); *ibid.* 1901, *op. cit.* (suppl.), p. 718; Draudt 1920, *in* Seitz, Gross-schmett. Erde 5: 780, pl. 155 g; Hoffmann 1941, An. Inst. Biol. (Mexico) 11: 712; Comstock & Huntington 1962, J. New York Ent. Soc. 70: 115.
Allosmaitia pion: Clench 1964, J. Res. Lepid. (1963) 2: 255.

One ♀, worn, Santa Ana Nat. Wildlife Refuge, nr. Alamo, Hidalgo Co., Texas, 11–xi–1968 (*leg.* R.O.K.).

This is an uncommon species in Mexico, occurring chiefly in scrub and low forest, particularly in montane areas. Hoffmann (*l.c.*) records it from no farther north than Tabasco and southern Veracruz. There are specimens in Carnegie Museum, however, from as far north as Sinaloa (19 mi E Concordia) and Hidalgo (7 mi N Zimapan, 1830 m).

Acknowledgment

To Harry K. Clench, Carnegie Museum, Pittsburgh, Penn., I wish to express my sincere appreciation for determining these specimens, reviewing this paper, providing the references cited, and furnishing additional distribution data for each species.

INEXPENSIVE PHOTOMICROGRAPHY

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Introduction

In essence, photomicrography usually consists of positioning a film several inches from the ocular lens of a compound microscope to receive the magnified image of the subject. A special camera, without lens, generally is used for this purpose; detailed descriptions are given in texts such as those by Allen (1941) and Shillaber (1944). An inexpensive camera may be used *without* removing the lens (Loveland, 1943), but this method has serious disadvantages, e.g. tendency of a "flare spot" (bright area in the center of the field) to appear in the picture.

Following is a brief description of construction and operation of homemade equipment of the camera-without-lens style using both negative-positive (conventional) and Polaroid processes.

Conventional Film

Apparatus.—The apparatus (Figure 1) consisted of two parts: (1) a wooden base, with generous working area, on which two rigid uprights



Fig. 1. Conventional-film camera, with 4 × 5 in. cut film holder in place, attached to 40–1000× binocular microscope (Jewell Optical Co.).

were mounted, and (2) a camera body, constructed of plywood, with an attached bellows (an inexpensive item purchased from Edmund Scientific Co., Barrington, New Jersey). The bellows allowed variation in magnification by changing the lens to film distance, which fortunately can be varied widely (actual focussing is done with the microscope adjustments). The camera body was mounted in a rectangle of ½ in. plywood with slots permitting attachment to the angle irons of the uprights using bolts and wingnuts (see Figure 2). The camera was painted flat black to minimize internal reflection and was designed with a hinged back (see rear view, Figure 2) to accommodate a 4 × 5 in. cut film holder as previously found suited for close-up (low magnification) photography of mounted Lepidoptera (Kolyer, 1965). Because the microscopes at hand all had eyepiece housings inclined at 45°, the camera was mounted at this angle.

To link the bellows to the microscope, a sleeve of black felt attached to the bellows was slipped over the eyepiece housing and held in place by wrapping with a piece of heavy copper wire. This method was found

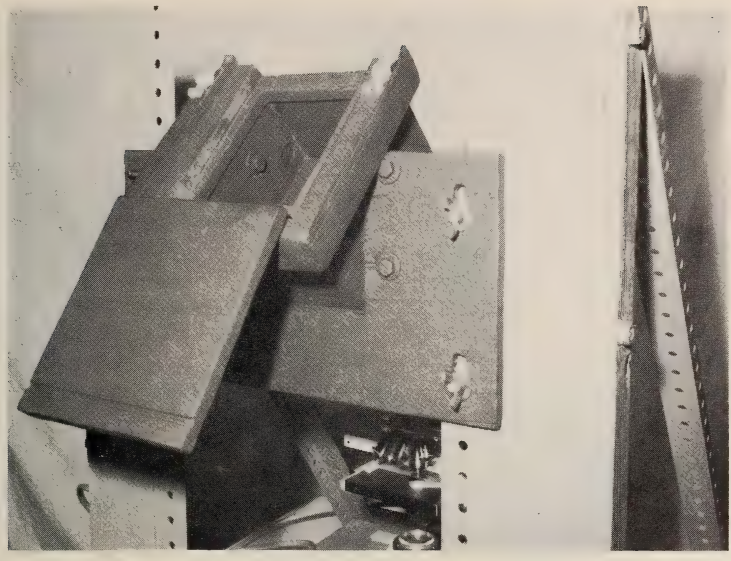


Fig. 2. Rear view of apparatus of Figure 1, showing hinged back open (film holder removed).

advantageous because the microscope was touched only by the felt, preventing marring of the instrument, and the connection was flexible so that microscopes with a movable tube (as opposed to the movable stage on some models) could be focussed while viewing the image on the ground glass.

A less-sturdy but satisfactory apparatus, so light in weight that it may be fixed to the microscope without additional support, can be constructed from cardboard (Anonymous, circa 1958). In fact, any design or materials are suitable provided that the film is held in the focal plane.

Procedure (*black & white*).—A rectangle of frosted glass was mounted on a 5 mm thick composition board frame so that, when inserted in place of the film holder, the frosted surface was at exactly the same distance from the eyepiece as the film. This was used to focus the image and then was replaced by a cut film holder. A film was exposed, and the illuminator was turned on for the desired exposure time (using the switch at lower right of Figure 1).

Excellent results were obtained with Kodak Plus-X Pan professional Film, Estar thick base, 4 × 5 in., developed according to the manufacturer's instructions. Using a Tasco 16× stereo microscope (shown, with a different camera, in Figure 3), with the Bausch & Lomb illuminator shown in Figure 3 set at highest intensity and positioned with the illuminator lens 4 in. from the specimen, optimum exposure time was 20 sec. The dis-



Fig. 3. Polaroid Model 220 camera, adapted for photomicrography, attached to a 16× stereo microscope (Tasco). Also shown is the Bausch and Lomb micro lamp (Nicholas illuminator) used in the examples in the text.

tance from microscope eyepiece lens to film surface was about 7.8 in. With the Jewell binocular microscope (Figure 1) at 1000× (10× wide-field eyepiece, 100× objective (N.A. 1.25) immersed in oil), longer exposures, e.g. 2 min., were required.

Prints (4 × 5 in.) were prepared with Kodak Azo F-3 paper by the contact method, using a relatively long distance (16 in.) between negative and light bulb (250 watts) to secure even light intensity over the whole print.

Procedure (color).—Kodak Ektachrome Color Reversal Film (for artificial light), Type B, 4 × 5 in., was used to make transparencies. Development was done at home with a Kodak Ektachrome film processing kit, E-3, one-gallon size. Because this film was more light-sensitive than the Plus-X Pan, exposure times were shorter, e.g. 1 sec. with the Tasco 16× microscope and illuminator positioned as above. With a 100× microscope, using a 10× objective (0.25 N.A.), more light was required.

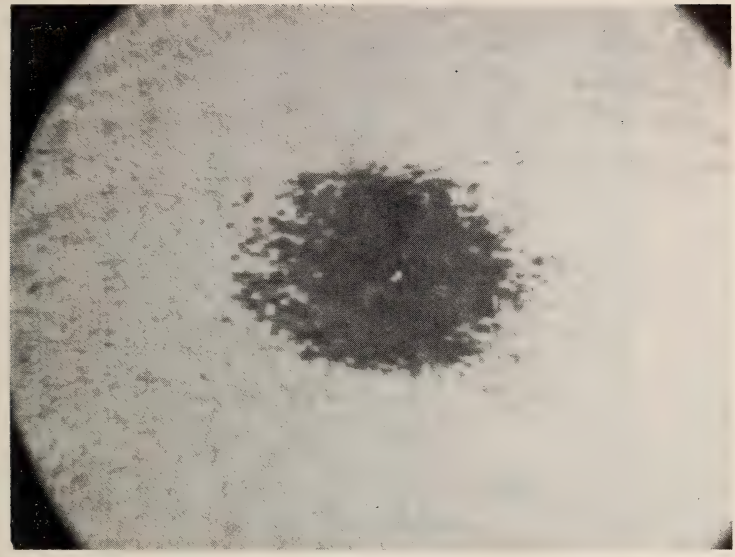


Fig. 4. Black spot on the forewing of *Pieris rapae* (L.) (♀), photographed with the apparatus shown in Figure 3.

A typical exposure time was 1 sec. with the B & L illuminator tilted 15° down from the horizontal and the lens of the illuminator only 1.3 in. from the subject.

POLAROID FILM

Apparatus.—A holder for 4 × 5 in. Polaroid film sheets is available which is dimensionally the same as a standard 4 × 5 in. cut film holder and will fit the apparatus described above, but this lists for about twice as much as the less-expensive Polaroid cameras. Also, the 4 × 5 in. Polaroid film is about twice as costly per photograph as the popular 3¼ × 4¼ in. black & white Polaroid film sold in packs of 8 (Type 107, ASA 3000). Therefore, a Polaroid Model 220 camera, intended to use both black & white and color film, was adapted by removing the lens and replacing with a wooden block with sliding aluminum insert which closed the opening between exposures and was drawn up to open the light path when photographs were being taken (as shown in Figure 3). The distance from eyepiece to film was about 8 in. Again, a frosted glass was used for focussing.

Procedure (*black & white*).—After focussing the image, the frosted glass was removed and replaced by a film pack (Type 107, ASA 3000). Successive photographs were made to optimize exposure time by trial



Fig. 5. A black scale from the spot shown in Figure 4, mounted in Permount (Fisher Scientific Co.) and photographed with the camera shown in Figure 3 attached to the microscope (at 1000×) shown in Figure 1. Localization of the pigment is suggested.

and error. Examples of satisfactory pictures are shown in Figures 4 and 5. In comparison to the above-described conventional film, the Polaroid Type 107 film is very fast (light-sensitive) so that less light is needed. In the case of Figure 4, illumination was provided by a Tensor lamp (G. E. 93 bulb, at high intensity) set at 45° and 7 in. from the subject; the Tasco microscope was used, as shown in Figure 3. Using a stopwatch, optimum exposure time was about 1.5 sec. (1 sec. was too short and 3 sec. too long for best intensity in the photograph). For Figure 5, the Jewell binocular microscope was used at 1000X as in a preceding example. An exposure time of 2–3 sec. was suitable.

Procedure (color).—The preceding procedures were repeated using a Polariod color film pack (ASA 75), 3¼ × 4¼ in. prints (8) as with the black & white. Since this is a slower film than the black & white 3000 speed, longer exposure times were necessary. With the 16× stereo microscope (B & L illuminator at 45° with illuminator lens 4.5 in. from subject), an exposure

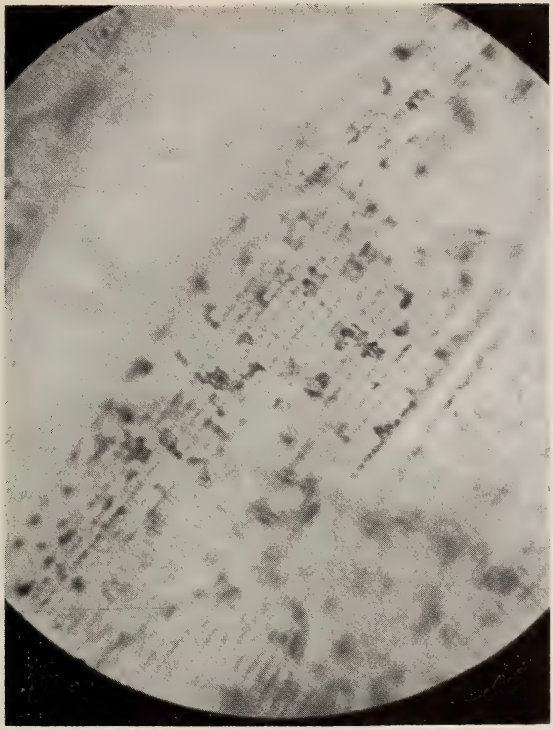


Fig. 6. A white scale from a wing of *P. rapae* which had been exposed to chlorine gas to stain the pterin pigment particles by murexide formation. This is a black & white reproduction of a Polaroid color picture taken with the apparatus used for Figure 5.

time of 10 sec. was suitable. With the 1000× microscope, 1 min. was too short (very dark print), 7.5 min. gave a somewhat dark print, and 11 min. (used for Figure 6) was satisfactory. The colors deviated considerably from reality but may serve to distinguish features stained differentially. In Figure 6, here reproduced in black and white, the irregularly-shaped particles on the scale were red-violet to the eye and appear dark violet (against a pale blue-green background) in the photograph.

Conclusion

A photomicrographic camera using conventional films may be home-made and give excellent results, but the inexpensive Polaroid cameras now available (color models for under $30) are readily adapted for photomicrography and offer the advantage of "instant" pictures using the popular, relatively low-cost film packs. Polaroid color photographs, useful

at least in cases of differential staining, are easily taken once exposure time has been optimized. Film cost is a little over 50¢ per color picture.

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NOTES ON THE GENUS *CEPHISE* EVANS, WITH A NEW RECORD FOR MEXICO (HESPERIIDAE)

H. A. FREEMAN
1605 Lewis Drive, Garland, Texas

When W. H. Evans (1952, p. 153) described the genus *Cephise*, he made the statement that the actual systematic position of the genus was doubtful. "The elongated wings and the conspicuous tornal lobe H indicate affinity with *Chrysoplectrum* in the *Urbanus* group, while the broad costa points to *Achalarus*. But the genitalia are not of the Urbanus type: the very broad-ended uncus with a snow-white dorsal tuft is peculiar. The proximity of veins 7 and 8 F rather than veins 6 and 7 point to the *Celaenorrhinus* group near *Nascus* and there is a similar sexual difference, F spots yellow in male, white in female, though not differing in size or disposition. The position in repose is unknown. ♂ upf with an unusually long costal fold, reaching to beyond the discal spots. Clasp with a slender style."

Evans also stated that there was but a single species, *cephise* (Herrich-Schaeffer) 1869, represented by two subspecies. In the nominate subspecies the cuiller of clasp is long, narrow and straight. The spot in space 1b in both sexes is against the outer edge of the spot in space 2. The subspecies is recorded from Honduras, Panama, Fr. Guiana, Surinam, Upper Amazons (St. Paulo d'Olivenca), Para, Ecuador and Peru. The other subspecies is *lydarnes* (Mabille) 1876, which has the cuiller of clasp broad and irregular. The females have the spot in space 1b on the upper surface of the primaries with the upper edge exactly against the lower edge of the

spot in space 2. This has been recorded from Matto Grosso, S. Brazil (Rio, Sao Paulo, Blumenau) and Paraguay. Actually, *cephise* and *hydarnes* represent separate species on the basis of their genitalia and the spot arrangement of the females.

During June 1969, while collecting on the grounds of Hotel Covadonga, six miles south of Ciudad Valles, S. L. P., Mexico, I caught two males and a female of *cephise*; this represents a new skipper record for Mexico. Observations made during this collecting period makes it possible to correctly place systematically the genus *Cephise*. The three specimens collected were found in rather dense jungle. Their flight pattern and position in repose is very similar to members of the genus *Urbanus*. During the middle of the day when the jungle is hot and still *cephise* rests on the under surface of banana leaves or other similar vegetation with the wings folded. When disturbed they dart out and fly for a short distance but before settling again will abruptly hit the underside of a leaf two or three times before coming to rest. This characteristic is also exhibited by members of the genus *Urbanus* and *Astraptes*. Apparently this approach will disturb any predatory spider which might be present; the jungle is full of such arachnids.

From information obtained by observing the habits of *Cephise cephise* I now rearrange the position of *Cephise* and place it between *Urbanus* and *Astraptes*. Certain morphological as well as the behavioral characteristics indicate that this is a much better arrangement than that of Evans in which it follows *Nascus*, a member of the *Celaenorrhinus* group the species of which hold their wings flat in repose.

Acknowledgment

I would like to express my appreciation to the American Philosophical Society for a research grant which made this study possible.

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OBITUARY

ALEXANDR SERGEEVICH DANILEVSKI

On the 27th of March, 1969, there died unexpectedly of heart failure at his home in Leningrad, the eminent Russian entomologist and lepidopterist, Dr. Alexandr Sergeevich Danilevski. Dr. Danilevski was the leading experimental insect ecologist and physiologist of the USSR, a prominent systematist of the Lepidoptera, and an authority on the Tortricidae or leaf-rollers. He was Dean of the Faculty of Biology and Agronomy and professor of Entomology at the University of Leningrad.

Dr. Danilevski was born on the 4th of March, 1911, near the town of Mirgorod, in the district of Poltava in the Ukraine. His father was an agronomist; his mother, a school teacher, was the granddaughter of the great Russian poet, A. S. Pushkin. Even as a schoolboy he was attracted to natural history and became a familiar figure at the Poltava Museum and Experimental Station. After finishing high school in 1930 he remained in Leningrad to enter the Institute of Applied Zoology and Phytopathology, where he completed his studies in 1933 with excellent marks. At that time he was already an experienced faunist and systematist of Lepidoptera. He took a post at the

Federal Institute for Plant Protection, where he studied the problem of food specialization in insects. His first scientific paper, which dealt with the results of his study, was published in 1935.

In 1936, Dr. Danilevski became reader at the University of Leningrad; his connection with this University lasted throughout the rest of his life and his entire scientific career.

During World War II he volunteered for military service and took part in the heroic defense of Leningrad. After the war he returned to Leningrad University, first as reader in the Department of Entomology, and since 1955 as its head. In 1967 he was appointed Dean of the Faculty of Biology and Agronomy. Concurrently during these years, Dr. Danilevski worked at the Zoological Institute of the Academy of Sciences of the USSR, where he headed the Division of Lepidoptera. He maintained a very close contact with this Institute until the last day of his life.

Dr. Danilevski's work on Applied Entomology and Phytopathology directed his interest to acute problems of plant protection and so paved the way for his later great ecological work. He studied the ecological regulation of population density and of biological cycles of pests, starting with the interrelation between pests and their food plants. When he undertook a study of distribution and acclimatization of certain lasiocampid species in the USSR, he viewed the problem from ecological and physiological aspects. His analysis showed that limits of an area of distribution cannot be explained solely by the ecological requirements of active insect stages, but that the resting stages of the life cycle must also be taken into account. This conclusion awakened his interest in diapause and the factors regulating it. The results of his studies on reactivation and adaptation of stages in diapause have become fundamental for the understanding of many problems of ecology and zoogeography.

A new step in the development of insect ecology was provided by his studies on photoperiodical adaptations. The influence of day-length on insect development had been discovered at the beginning of the present century, but Dr. Danilevski was the first to realize the great importance of this aspect of the regulation of diapause, and of other cyclic seasonal phenomena. He showed the wide occurrence of the photoperiodic reaction in insects, demonstrated the diversity of its occurrence, and determined the geographical variability of the reaction and its dependence on temperature, food, and other factors of the environment. He was the first to study the hereditary, as well as many other aspects of the photoperiodic reaction. As the final result of his research, he defined the ecological mechanism of the regulation of the life cycle in insects. A theoretical conclusion of his research was his monograph and doctoral thesis: "Photoperiodism and seasonal development of insects" (1961), for which he was awarded a first prize by Leningrad University. This book has been published in translation in England and Japan, and is generally recognized as one of the classic works on invertebrate ecology.

To the end of his life Dr. Danilevski continued the study of photoperiodism and so erected a school of ecologists. In 1968 his pupils published a symposium entitled "Photoperiodical Adaptation in Insects and Acari," in connection with the XIIIth International Congress of Entomology.

He was also a talented and devoted teacher and had a large number of ardent pupils ranging from University lecturers and students to school teachers and school children, for all of whom he organized entomology classes.

At the same time, Dr. Danilevski was very active in the field of the systematics of Palaearctic Lepidoptera. When still quite young and under the influence of the Russian lepidopterist, N. N. Filipjev, he made special study of the Tortricidae or leaf-rollers and soon became a great authority on this group of Microlepidoptera. In all, he described over seven new genera and 60 new species, chiefly of the Tortricidae; he was also an authority on lepidopterous larvae. He edited the late A. M. Gerasimov's monograph on the caterpillars of the USSR and made many additions from his own

knowledge. He compiled keys to insect orders based on last larval stages, and published a fauna of dendrophilous larvae of Lepidoptera of the USSR.

In systematics, Dr. Danilevski applied not only the classical methods but used his fundamental knowledge of ecological data. All his purely taxonomical papers have an ecological approach, so valuable, but so often completely lacking in the work of others. This approach is evident in the recent (1968) monumental monograph on the tribe Laspeyresiini of the USSR (tortricid fruit-borers), which was published by him and his pupil V. I. Kuznetsov. This is unquestionably the best treatise on the group to have appeared within the last hundred years.

The scientific merits of Dr. Danilevski have been acknowledged both in his own country and abroad. He was member of the Board of the Federal Entomological Society of the Scientific Advising Committee of Leningrad University, of the Zoological Institute of the Academy of Sciences, and of the Federal Institute for Plant Protection. He was also a member of the Editorial Board of *Entomologicheskoye Obozreniye* and of the international journal *Insect Physiology*.

Besides his scientific qualifications, Dr. Danilevski was a most amiable and kindly man, a lively and interesting companion, and a warmly sociable person. His so unexpected and much too early death cannot but be a severe loss for all his friends, students, and colleagues as well as for lepidopterology in the USSR and abroad.—A.

DIAKONOFF, *Rijksmuseum van Natuurlijke Historie, Leiden, Netherlands.*

MATING FLIGHT OF BUTTERFLIES WITH MIMETIC FEMALES AND NON-MIMETIC MALES

Although no records were kept and it is therefore impossible to cite precise dates and localities, the mating of the following five species has been observed with some frequency over a good many years. In all cases the female was the active partner and the nuptial flight took place in the afternoon, but earlier for *Hypolimnas misippus* L. than for the species of Papilionidae.

Papilionidae:

Papilio polytes L. Mysore, (S. India) and Ceylon, 1939
Papilio dardanus Brown. Rhodesia and East Africa, 1940–1968
Papilio echerioides Trimen. Kenya and Ethiopia, 1940–1968
Papilio jacksoni Sharpe. Kenya Highlands, 1955–1968

Nymphalidae:

Hypolimnas misippus L. East Africa, 1955–68, Aldabra Island, (Indian Ocean, March 1968)

The species listed above show very conspicuous sexual dimorphism, and there is no possibility of error. It is also logical that these species should be protected by exposure of the (mimetic) female pattern during the very slow and vulnerable mating flight. It is likely that most species with mimetic females and non-mimetic males behave in a similar fashion, but the matter requires further study.—R. H. CARCASSON, *Centennial Museum, Vancouver, British Columbia, Canada.*

MINUTES OF THE SIXTEENTH ANNUAL MEETING OF THE PACIFIC SLOPE SECTION OF THE LEPIDOPTERISTS' SOCIETY

SEPTEMBER 5–7, 1969, LOS ANGELES, CALIF.

FRIDAY, SEPT. 5

The formal meetings took place at the Los Angeles County Museum of Natural History in Exposition Park. On Friday afternoon some of the early arrivals visited the Entomology Section in the museum building. The collections were available for study, and as is known by many, it is especially rich in Lepidoptera; it contains many older specimens taken by pioneer collectors in the "classic" Southern California localities. Dr. C. L. HOGUE was host, and as member of the program committee, arranged the subsequent dinner, luncheon and banquet.

Later, an informal social gathering for cocktails and dinner took place at a nearby restaurant on Figueroa St. This included a few of the later arrivals. Proceedings gained momentum with an after-dinner "beer-bust" at an adjoining "water-hole."

SATURDAY, SEPT. 6

Members and guests gathered at the museum building for registration and informal discussion. Coffee and doughnuts, compliments of the Lorquin Entomological Society, were available.

Shortly after 10 a.m. the meeting was called to order by Dr. C. L. HOGUE. R. L. LANGSTON was unanimously elected Secretary *pro tem*. Dr. J. W. TILDEN was elected chairman of the Resolutions Committee.

The Address of Welcome by Dr. HERBERT FRIEDMANN, LACMNH Museum Director was read in his absence by Dr. HOGUE.

The Presidential Address by Dr. DAVID HARDWICK, Canada Dept. of Agriculture was also read in his absence. It was stated that the 1970 meeting will be held in conjunction with the National Meeting in Carson City, Nevada.

E. J. NEWCOMER, Yakima, Wash., informed the group that, on the basis of the mailings of the NEWS, the Society has enjoyed a 33% increase in members.

Dr. HOGUE announced the retirement of LLOYD M. MARTIN on July 31, 1969, and that at the time of the meetings, Mr. MARTIN was visiting museums in Europe. A "Best Wishes" card was placed at the coffee table, to be signed by the Lepidopterists.

The Saturday morning session included two formal presentations:

***Papilio* hybrid studies**—FRED THORNE, El Cajon, Calif.

Hand pairing of *Papilios*—WILLIAM HEDGES, Lakeside, Calif.

A showing of slides, with CARL GOODPASTURE as projectionist included:

Nevada collecting spots—PETER HERLAN, Carson City, Nevada

Alaskan butterfly life—KENELM PHILIP, Fairbanks, Alaska (narrated in his absence by Carl Goodpasture).

***Colias* of the Palearctic compared to the Nearctic**—WILLIAM HOVANITZ, Arcadia, Calif.

Collecting spots in Oregon—Warners, Steen Mtns.—E. J. NEWCOMER, Yakima, Wash.

Speyeria leto pugatensis, gynandomorph from northwestern California—STERLING MATTOON, Chico, Calif.

"The five mountain ranges around Albuquerque" plus slides of *Speyeria*, *Catocala*, etc.—RICHARD HOLLAND, Albuquerque, New Mexico.

The meeting was then adjourned for a group luncheon at the restaurant on Figueroa St. Generous portions were served, and no long speeches occurred.

At 1:35 p.m. the meeting was called to order by Dr. J. W. TILDEN. MRS. CHARLES

HOGUE was introduced as the hostess for the Saturday afternoon LADIES PROGRAM. The program included a visit to the Los Angeles County Museum of Art.

The Saturday afternoon session consisted of several studies:

Distributional patterns of California moths—RONALD LEUSCHNER, Gardena, Calif.

Microlepidoptera associated with oaks in California—PAUL OPLER, Albany, Calif.

Mechanisms of sex pheromone communication among moths—HARRY SHOREY, Riverside, Calif.

A brief coffee-doughnut break ensued, then back to the tight schedule.

A collecting trip in northern latitudes and **"Rediscovery of *Pieris napi colei*"**—DON EFF, Boulder, Colorado (read in his absence by Dr. Tilden).

An OPEN FORUM on NOMENCLATURE was next on the agenda, led by the following panelists:

PADDY MCHENRY, Burbank, Calif.—**"Introduction to nomenclature."**

E. J. NEWCOMER, Yakima, Wash.—**"Pronunciation."**

Lively discussion followed, but was cut short because of the lateness of the hour. Before closing, Dr. J. A. POWELL, Berkeley, Calif., gave a report on the Lepidopterists' SOCIETY meeting in East Lansing, Michigan, June 16–17, 1969. The meeting was then adjourned by Dr. TILDEN at 5:10 p.m.

The annual banquet was held at the Cockatoo Inn in Hawthorne, several miles down the freeway and dozens of stop-signals later. Following the sumptuous dinner, there was a showing of the EUGENE O. MURMAN transparencies. These paintings shown through two projectors (some to indicate iridescence) were mostly of North American butterflies. It was ably narrated by Dr. JOHN GARTH, Allan Hancock Foundation, Los Angeles, Calif.

SUNDAY, SEPT. 7

Members and guests again gathered at the LACMNH, with the meeting being called to order shortly after 9 a.m. by Dr. HOGUE.

ELTON O. SETTE presided over the Sunday session, at which the following papers were presented:

Co-existence of *Plebejus* in Southern California—CARL GOODPASTURE, Pasadena, Calif.

Relationships within the *acmon* group of *Plebejus*—Dr. J. W. TILDEN, San Jose, Calif.

A short break was then taken to partake of coffee and doughnuts, again furnished by the Lorquin Entomological Society. The program resumed with:

Butterflies of five central New Mexico mountain ranges—RICHARD HOLLAND, Albuquerque, New Mexico.

Notes on rearing *Speyeria*—STERLING MATTOON, Chico, Calif.

Evolution in the genus *Argynnis*—Dr. WILLIAM HOVANITZ, Arcadia, Calif.

***Anthocaris* bionomics and distribution in the Great Basin**—Rev. DAVID L. BAUER, South Lake Tahoe, Calif.

The "Collecting reports" next on the agenda were omitted because of the very crowded schedule. However, several Lepidoptera collections by various members had been on display during the two days, and reprints and mimeographed papers were made available.

The business meeting was then convened by ELTON O. SETTE.

The Society Library: Dr. PETER BELLINGER, Northridge, Calif. reported on the status of the library. It has expanded considerably with the addition of many books and reprints. Also on file are the field season reports. Numerous scientific journals are received in exchange for our JOURNAL. These materials are available to all members, to borrow either in person or by mail.

Treasurer's report: NELSON BAKER, Santa Barbara, Calif., reported that $95 is on deposit in the account. An additional $39 was received from registrations at the cur-

rent meeting. However, from this, more than $12 was paid for banquet entertainment. Another $10 was used for postage and program printing. It was moved that the treasurer secure a permanent record book. A vote of confidence was given Nelson Baker to continue as the Pacific Slope Treasurer, with checking account rights to be extended to Dr. Hogue.

Dr. J. W. TILDEN, Chairman, proposed the following resolutions:

1) That a vote of thanks be extended to Dr. Friedmann and the staff of the Los Angeles County Museum for use of the facilities of the museum.
2) Also to Charles Hogue, Lloyd Martin, and Fred Thorne for their work in planning the program and making arrangements for the meetings.
3) Also to the Lorquin Entomological Society for providing the coffee and snacks.
4) That the Secretary *pro tem.* be asked to extend to the President and Society an invitation to meet jointly with the Pacific Slope Section in 1970 at Carson City.
5) That members of the Society and Registrants, wishing to take this opportunity of acknowledging the contributions of Lloyd Martin to the Society and its individual members, extend their greetings to Mr. Martin on the occasion of his formal retirement, in the hope and expectation that he will in fact continue his activity for many more years.
6) That it is the sense of this meeting that the Lepidopterists' Society should begin appropriate action, as a body, and in conjunction with other organizations, to obtain protection for endangered species of insects, other animals and plants, and to preserve the natural ecology of North America and the rest of the World.

The first five were either passed or approved by acclamation. The sixth point on conservation entailed further discussion.

A motion was made by Fred Thorne that a committee be appointed for the Society to enter into the field of conservation. Paul Opler stated that the conservation issue had already been discussed at the National meeting. Further discussion revealed that conservation is a matter to be considered by the Society as a whole. Several people expressed opinions for and against. Subsequently the whole matter was tabled.

It was moved by Fred Thorne that the Society congratulate Peter Bellinger on the wonderful library work. Approval was unanimous.

Selection of 1970 meeting place and date: Paul Opler and Jon Shepard were on the committee for merging the National meeting with the Pacific Slope meeting, and Carson City was chosen. The location was agreeable to President Hardwick, Peter Herlan and others concerned. Charles Harbison suggested that the last weekend in June would be appropriate. This was not acted upon, but Herlan stated that any summer date chosen would be agreeable to the eastern group. Dr. Tilden proposed that we accept the recommendations from the established (Opler) committee. Dr. Powell amended the motion to accept in advance that date for the meeting ultimately decided on by the (to-be-elected) Program Chairman. Nelson Baker moved that we choose a definite date. The original (Tilden) motion was passed after much interim discussion. The amendment (Powell) was withdrawn by Powell. In summary, Noel La Due moved that the time and place be selected by the Program Committee. The motion passed, but most present were confused by this time. Opler moved that Herlan be in charge of local arrangements, and that David L. Bauer and Tilden be co-chairmen of the program committee. The motion was passed.

Selection of site for 1971 meeting: Paul Opler moved that the 1971 program committee be selected by the chairman of this session (Sette). Sette selected Thorne as Chairman, with the latter to be assisted by McHenry and Powell. The selection was approved.

Amid a last minute flurry of discussion and general visiting, the meeting was noisily adjourned. A few of the lingering members had a late lunch in the museum cafeteria; these and others also re-visited the Entomology Section.

ATTENDANCE

Although most delegates were from California, five other states were represented. Members, guests and speakers who attended all or part of the meetings and banquet included:

N. W. Baker & wife, D. L. Bauer, P. F. Bellinger, R. W. Breedlove, C. J. Callaghan (Utah), J. F. Emmel, M. Eloas, G. S. Forbes, J. Garth & wife, C. Goodpasture, C. F. Harbison, W. A. Hedges & wife, J. B. Heppner, P. J. Herlan (Nevada), C. L. Hogue & wife, R. Holland (New Mexico), W. Hovanitz & wife, K. C. Hughes, W. Klein, N. La Due & wife, J. Lane & date, R. L. Langston, R. Leuschner & wife, S. Mattoon & wife, P. McHenry, J. R. Mori, E. J. Newcomer (Washington), P. A. Opler & wife, B. Perkins & wife (Oregon), J. A. Powell, C. Quick, A. Rubbert & wife, C. A. Sekerman, O. E. Sette, O. A. Shields, H. Shorey, J. S. Snider, W. L. Swisher, Fred Thorne, K. Tidwell & wife (Utah), J. W. Tilden & wife, and M. Toliver (New Mexico).

ROBERT L. LANGSTON (*Secretary pro tem.*), *3 Arlington Ave., Berkeley 7, Calif.*

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE
A. (n. s.) 85

Required six-month's notice is given on the possible use of plenary powers by the International Commission on Zoological Nomenclature in connection with the following names listed by case number:

1867. Suppression of Huebner's pamphlet *Der Schmetterlinge Lepidoptera Linnaei europäisches Heer*, circa 1790–1793.
1875. Suppression of *Papilio saportae* Huebner, 1828/32 (Insecta, Lepidoptera).
1876. Type-species for *Agrotiphila* Grote, 1875 (Insecta, Lepidoptera).

Comments should be sent in duplicate, citing case number, to the Secretary, International Commission on Zoological Nomenclature, c/o British Museum (Natural History), Cromwell Road, London S.W.7, England. Those received early enough will be published in the Bulletin of Zoological Nomenclature.
November 1969

W. E. CHINA, *Assistant Secretary to the International Commission on Zoological Nomenclature.*

NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Shorter articles are favored, and authors will be requested to pay for material in excess of 20 printed pages, at the rate of $17.50 per page. Address all correspondence relating to the *Journal* to: Dr. D. F. Hardwick, K. W. Neatby Bldg., Central Experimental Farm, Carling Ave., Ottawa, Canada.

Contributors should prepare manuscripts according to the following instructions; failure to do so will result in unnecessary delay prior to publication.

Text: Manuscripts must be typewritten, *entirely double-spaced*, employing wide margins, on one side only of white, 8½ × 11 inch paper. Authors should keep a carbon copy of the MS. *Titles* should be explicit and descriptive of the article's content, including the family name of the subject, but must be kept as short as possible. The first mention of a plant or animal in the text should include the *full scientific name, with authors* of zoological names. Underline *only where italics* are intended in the text (never in headings). References to footnotes should be numbered consecutively, and the footnotes should be typed on a separate sheet.

Literature cited: References in the text should be given as, Comstock (1927) or (Comstock 1933, 1940a, 1940b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

COMSTOCK, J. A. 1927. Butterflies of California. Los Angeles, Calif. 334 pp.
———— 1940a. Notes on the early stages of *Xanthothrix ranunculi*. Bull. So. Calif. Acad. Sci. 39: 198–199.

Illustrations: All photographs and drawings should be mounted on stiff, *white* backing, arranged in the desired format, for reduction to the page size (4½ × 7 inches), *including space for legends*. The author's name, figure numbers as cited in the text (where these are not intended to be engraved on the plate), and an indication of the article's title should be printed *on the back* of each mounted plate. No charges are made to authors for line drawings or halftone (photographic) figures, provided these are submitted in satisfactory condition for reproduction without touch-up work. Figures, both line drawings and halftones, should be numbered consecutively in Arabic numerals. The term "plate" should not be employed. *Figure legends* must be typewritten, double-spaced, *on a separate page* (not attached to the illustrations), headed EXPLANATION OF FIGURES, with a separate paragraph devoted to each page of illustrations.

Proofs: The edited MS and galley proofs will be mailed to the author for correction of printer's errors. Excessive author's changes at this time will be charged to authors at the rate of 75¢ per line. A purchase order for *reprints* will accompany the proofs.

Tables: Tables should be numbered consecutively in Arabic numerals. Headings for tables should not be capitalized. Tabular material should be kept to a minimum and must be typed *on separate sheets*, and placed following the main text, with the approximate desired position indicated in the text. Vertical rules should be avoided.

Material not intended for permanent record, such as current events and notices, should be sent to the editor of the *News*: Dr. C. V. Covell, Dept. of Biology, University of Louisville, Louisville, Kentucky 40208.

Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA
by CYRIL F. DOS PASSOS

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THE ENVIRONMENTAL REGULATION OF SEASONAL DIMORPHISM IN *PIERIS NAPI OLERACEA* (PIERIDAE)

CHARLES G. OLIVER
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The causes of seasonal changes in the coloration, wing marking pattern, and even wing and body structure of Lepidoptera have long been an intriguing subject for experimentation. The changes may be of two basic types: either a marked but continuous shift in intensity and extent of pattern elements or ground color, or a sharply defined dimorphism in which colors and pattern elements may be completely replaced and changes in wing and body structure may occur. The former type is common in continuously brooded species such as *Colias eurytheme* Boisduval and *Phyciodes tharos* Drury, while the latter occurs most often in discretely brooded species such as *Araschnia levana* L. and *Celastrina argiolus* L.

Two chief factors, temperature and photoperiod, have so far been shown to be of importance in regulating seasonal forms. In *Precis octavia* Cramer the effect is caused entirely by rearing temperature (McLeod, 1968). The appearance of female *Ascia monuste* L., which may vary in color from white to dark gray (Pease, 1962) and the seasonal dimorphism of *Pieris protodice* Boisduval & LeConte (Shapiro, 1968) are, on the other hand, due to daily photoperiod exposure during the immature stages. The forms of other species such as *Araschnia levana* (Süffert, 1924; Müller, 1955, 1956) and *Colias eurytheme* (Ae, 1957) apparently are regulated by a synergism between temperature and photoperiod.

Pieris napi oleracea Harris is sharply bivoltine in eastern North America. The spring and summer broods differ markedly in body to wing size proportions and in the extent and intensity of wing pattern (Table 1). The experiments described here were designed as an attempt to produce the seasonal forms shown in nature using temperature and photoperiod as controlled variables.

TABLE 1. Differences in appearance between "spring" and "summer" phenotypes of *Pieris napi oleracea*.

"Spring" phenotype	"Summer" phenotype
1. Body relatively stout, dark, hairy.	Body relatively slender, lighter-colored, smooth.
2. Dorsal dark scaling at wing bases and forewing apex heavy.	Dorsal dark scaling light.
3. Scaling along veins on underside of hind wing always very dark, complete, clear-cut.	Scaling along veins on underside of hind wing varying from light and complete, to light and incomplete, to absent.

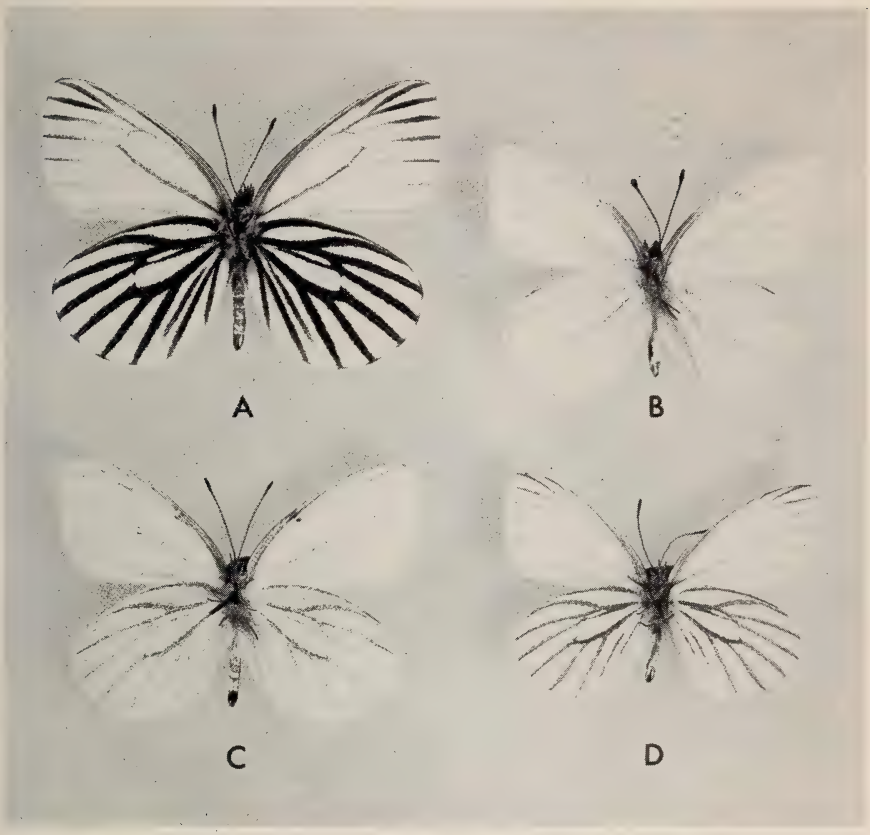
Procedure

Four broods of *P. n. oleracea* were derived from wild-inseminated females collected 15 May 1968 at Wahconah Falls State Park, Berkshire Co., Massachusetts. The newly hatched larvae of three of the females were divided into two lots for rearing both on long days, short nights (15hL/9hD) and on short days, long nights (12hL/12hD), while those of the fourth female were reared only on long days, short nights. All of the larvae were fed on cut mustard leaves (*Brassica*) and given a 25° C day and a 22° C night.

None of the pupae produced from long-day larvae entered diapause, and are hereafter referred to as the non-diapausing pupae. Among these emergence or death occurred in every case within six to ten days. None of the pupae produced from short-day larvae had emerged after two to three weeks and were thus presumed to have entered diapause (the diapausing pupae). They were placed at 5° C in darkness for 10 weeks to terminate diapause.

Immediately after pupation the non-diapausing pupae were subdivided into four lots and redistributed to await adult development under the following temperature and photoperiod regimes: 25° C day, 22° C night, 15hL/9hD (N = 14); 25° C day, 22° C night, 12hL/12hD (N = 13); 25° C day, 15° C night, 16hL/8hD (N = 12); 25° C day, 5° C night, 16hL/8hD (N = 18). Mortality of the pupae was 8/65 (12.3%), due probably in some cases to cold shock.

The diapausing pupae were left on their larval temperature and photoperiod regimes until the onset of chilling. After removal from cold, they were subdivided into three lots, all kept on long days and at 25° C during the day, but with night temperatures of 22° C (N = 14), 15° C (N = 8), 5° C (N = 8). Hatching of 30/43 (69.8%) of the pupae occurred six to 18 days after removal from cold. The death of another pupa occurred before 18 days after chilling, while the other 12 pupae were kept at



Figs. A–D, *Pieris napi oleracea*, ventral view of males. A, "Spring" adult from diapausing pupa; B–D, extreme light, medium, and extreme dark "summer" adults from non-diapausing pupae. (All laboratory-reared progeny of wild-caught females from Berkshire Co., Mass., 15 May 1968.)

room temperature for several months and gradually desiccated without ever hatching.

Results

The results were unequivocal. In each case the non-diapausing pupae produced adults typical of the "summer" phenotype, while the diapausing pupae produced typical "spring" adults. There was no correlation of phenotype to any environmental factor except larval photoperiod exposure. Each of the four broods gave the same range of adult variation in coloration as found in the wild summer emergence (Table 1 and Figs. C and D). The diapausing pupae gave adults all almost identical in

appearance to each other, regardless of pupal photoperiod and temperature regime (Figs. A and B).

Discussion

Clearly the basic environmental factor determining seasonal form in *P. napi oleracea* is larval photoperiod exposure. However, it is impossible as yet to say whether it is larval photoperiod itself or the occurrence of diapause in the pupa that actually directly determines which phenotype is to be produced, since larval photoperiod and diapause cannot here be separated.

It is interesting that even though part of the non-diapausing pupae were chilled overnight during the time when adult wing pigment was being formed, there was no darkening effect at all shown in the emerging adults. This seems to be in contradiction to Merrifield's (1893) report that chilling summer pupae of British *P. napi* L. caused the emerging adults to have "most, but not all, of the characteristics of the spring form." Merrifield's pupae were, however, chilled for three to four months prior to exposure to spring (average 54° F) or summer (average 80° F) conditions during development. There was no further intensification of dark markings in the lot exposed to spring conditions. Probably the pupae had entered diapause at the onset of the three or four months of chilling, but it may be that *P. n. napi* has a rather different system for the regulation of seasonal forms from that of *P. n. oleracea*.

The results indicate that *P. n. oleracea* in eastern North America has two systems that regulate the appearance of the adult phenotype. The first is the inherited, environment-independent expression of dark wing markings in the "summer" form. This system is responsible for the individual variation found in the summer brood. The second is the environmentally induced "switching on" of the "spring" form. Since this involves uniformly maximum expression of the characters that show variation in the summer form, as well as new differences, any genetic variation in wing pattern that would be revealed in the summer brood is concealed in the spring brood.

Summary

Diapausing and non-diapausing pupae of *Pieris napi oleracea* were exposed to various photoperiod and temperature regimes during adult development. The pupae which had undergone diapause produced only adults of the "spring" form, whereas those that had not, produced only adults of the "summer" form. Regulation of seasonal dimorphism is thus

controlled by larval photoperiod exposure, which also controls the induction of pupal diapause.

Acknowledgment

I thank Dr. Charles L. Remington for his helpful advice during the preparation of this paper.

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A PLASTIC RELAXING BOX FOR PINNED AND PAPERED SPECIMENS

Robert S. Rozman

9704 Belvedere Place, Silver Spring, Maryland

This relaxing chamber can be readily made by anyone with average mechanical ability for just a few dollars. The setup offers several advantages over regular relaxing chambers. First, pinned specimens can be readily relaxed without the rapid rusting resulting from pins being stuck directly into wet sand. Second, envelopes are not in direct contact with the wet sand. Although specimens take slightly longer to relax, they do not become soaked and ruined. Third, the clear plastic enables one to observe the conditions of the specimens during relaxation without opening the box.

The box and lining strip are of clear plastic, such as Plexiglas, available from hobby shops in 3/16 inch thickness. Sections can be bonded together

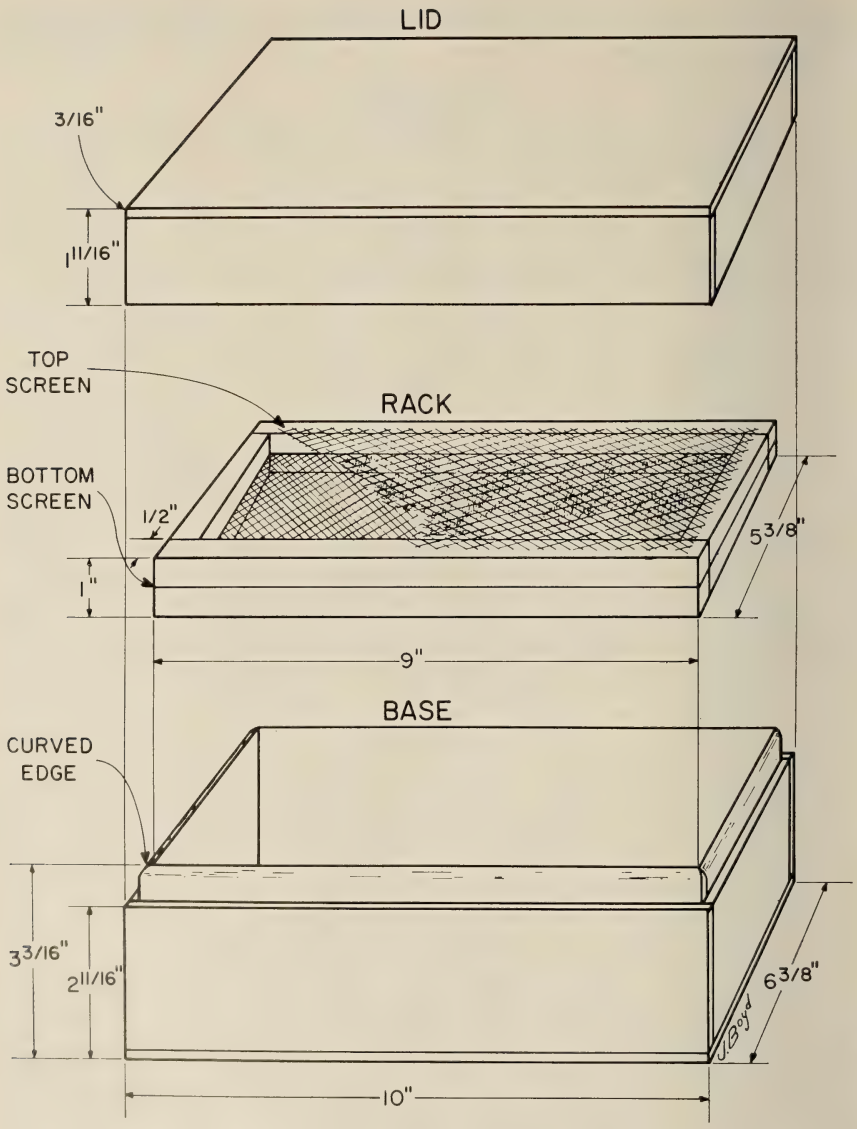


Fig. 1. Details of relaxing box and rack.

with a cement such as Duco Cement which will fill up any spaces formed by irregular sawing techniques. This will form watertight joints. If all edges are made planar and properly perpendicular, a neater bond can be made by injecting acetone or other plastic solvents along the seams.

Details of the box are given in Figure 1. Of course, the dimensions may be changed as desired, as long as the resultant base is watertight. As can be seen, the beveled inner strip serves to hold the lid securely as in a regular insect box or drawer.

About ¼ inch of wet sand is placed on the bottom and a teaspoonful or so of chlorocresol sprinkled over the sand to prevent mold (Tindale, 1961). A rack to hold the specimens is laid over this (Fig. 1). The frame, held together with Duco Cement, is made of polyurethane foam of the sort sold as Christmas decorations. The two screens are regular aluminum screening available at any hardware store. These are cemented to the top and center of the frame. In use pins are held upright by the two layers of screening or envelopes are laid over the frame.

I have been using this type of chamber and rack for some time now. Even fragile specimens don't usually break. The original screening is still shiny, the plastic still clear and the seams still watertight. I have yet to get mold or infestation, even without prior fumigation.

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A REDESCRIPTION OF *STRYMON BOREALIS* LAFONTAINE[1] (LYCAENIDAE)

J. D. LAFONTAINE
916 Innswood Dr., Ottawa, Ont.

Satyrium boreale (Lafontaine) **new combination**

Strymon borealis Lafontaine, 1969. Trail and Landscape 3: 151.

Upper surface of both sexes dark blackish-brown with no trace of an orange spot at the anal angle of the secondaries. Male stigma elliptical and light grey.

Undersurface of the male slightly lighter than upper surface. Postmedial band of primaries usually broken into three bands, separated by veins M_3 and Cu_2. Marginal side of the postmedial band lined with white; basal side with very little or no trace of white edging. Subterminal line of primaries usually reduced to only two spots between veins M_3 and Cu_2. The anterior three and the posterior spots of the subterminal line present in *falacer* (Fig. 5) and *caryaevorum* (Fig. 6) usually completely absent; occasionally very faint traces of these spots visible; if so, the posterior spot with a trace of white only, never with any trace of black. Secondaries of the male

[1] The name was inadvertently validated in *Trail and Landscape*. A redescription therefore seems appropriate.



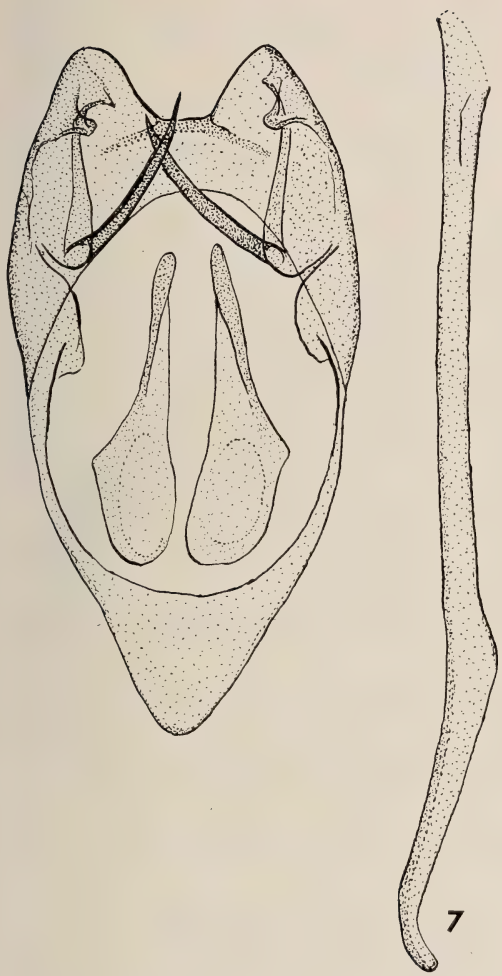
Figs. 1–4. *Satyrium boreale* Lafontaine. 1, Underside of male lectotype. 2, Upper side of male lectotype. 3, Underside of female. 4, Upper side of female.
Fig. 5. *Satyrium falacer* (Godart), underside of male.
Fig. 6. *Satyrium caryaevorum* McDunnough, underside of male.

with postmedial band irregular as in *falacer*. Subterminal line usually reduced or absent above vein M_3.

Undersurface of female (Fig. 3) similar to male (Fig. 1). Postmedial band of primaries more usually separated into distinct spots than in male. Subterminal line not so reduced as in male but clearly reduced, especially so on posterior (sixth) spot of this line. Secondaries similar to those of male but subterminal line not so reduced. Wingspread 25 to 29 mm.

Male genitalia (Fig. 7) like those of *falacer* except for shape of saccus. Saccus of *boreale* narrowing evenly throughout its length; that of *falacer* strongly constricted subbasally giving it the appearance of an inverted bell (Fig. 8).

Lectotype here designated: ♂ Britannia Park, Ottawa, Ont., July 4, 1966, J. D. Lafontaine. No. 11077 in the Canadian National Collection, Ottawa.



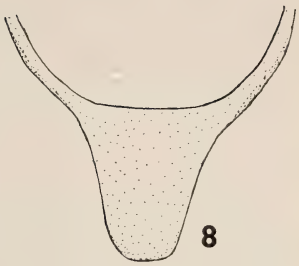


Fig. 7. *Satyrium boreale* Lafontaine, male genitalia.
Fig. 8. *Satyrium falacer* (Godart), saccus of male genitalia.

This species can be separated from *caryaevorum* by the incomplete subterminal line and the much more obscure postmedial band. It is very similar to *falacer* but can be separated by the subterminal line of the primaries. A specimen of *boreale* which has a trace of all six subterminal spots can be separated from a specimen of *falacer* with an unusually reduced subterminal line, by the posterior spot of this line. In *falacer* this spot has a trace of black but in *boreale* there is only a speck of white with

no black present. The subterminal line of the females of both species is better defined than in the males. The subterminal line in a *boreale* female is often almost as well defined as in a *falacer* male.

Boreale is usually collected on or around ash (*Fraxinus*), and *Acer negundo* L.

Distribution: S. Que. west to Mich., south through Ohio and Penn.

Acknowledgment

I wish to thank Dr. T. N. Freeman of the Entomology Research Institute, Canada Department of Agriculture, for his guidance in the preparation of this paper.

A NEW SPECIES OF *CAMERARIA* ON BUR OAK IN MANITOBA (GRACILLARIDAE)

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During the past few years some officers of the Forest Insect Survey of Canada, Department of Fisheries and Forestry, have been studying the biology of an undescribed species of *Cameraria* Chapman which is reported to be abundant on bur oak, *Quercus macrocarpa* Michx. in the vicinity of Winnipeg. The description of it is presented here to assist those officers in the publication of the results of their investigations.

Cameraria macrocarpae Freeman, **new species**

General. Antenna white, banded with dark fuscous dorsally. Face white. Tuft white with a few ochreous scales. Thorax golden dorsally and with a few white scales. Forewing shining golden ochreous with three, equally spaced, outwardly angulated, white, transverse fasciae; first at basal one-quarter, second near middle, and both margined outwardly below angle with black scales; the third at outer four-fifths margined with black scales throughout its length; a short, white, subapical, costal streak followed by an area of scattered black scales in middle of wing; fringe pale grey with a black basal line in tornal region. Hind wing light grey; fringe whitish. Abdomen pale ochreous. Legs whitish with small black patches outwardly. Wingspread: 8.0–8.5 mm.

Male genitalia (Fig. 1). Uncus sub-triangular. Clasper clavate. Aedeagus clavate. Ventral flap sub-conical.

Type material. Holotype male, Bird's Hill, Manitoba, 10 April 1968 (reared in laboratory). No. 11033 in the Canadian National Collection. Paratypes: one male, Bird's Hill, 13 March 1968; four males, one female, Bird's Hill, 22 April 1969; one male, Bird's Hill, 27 April 1969 (all reared in laboratory).



Fig. 1. Male genitalia of *Cameraria macrocarpae* Freeman.

Mine. A large upperside blotch containing several larvae.
Flight period. Late July to late August.

Remarks. This species is allied to the *Myrica* feeding *Cameraria picturatella* (Braun) **n. comb.** It may be separated by the presence of three, transverse fasciae on the forewing as opposed to one fascia on that of *picturatella.*

CONSIDÉRATIONS SUR LE MÂLE D'*ORNITHOPTERA ALLOTTEI* ROTHSCHILD ET SUR LA PHYLOGÉNIE DES ORNITHOPTÈRES

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ABSTRACT

Ornithoptera allottei is a species that shows a large number of characters that are intermediate between *priamus* and *victoriae*. A detailed examination has showed that these species do not form a progressive sequence of unilinear specialisation as it might seem, but that *priamus* and *victoriae* have evolved in opposite directions, with *allottei* representing an intermediate and more primitive condition. An explanation is given of the gradual changes in wing patterns throughout *Troides*, *Trogonoptera*, *Schoenbergia* and *Ornithoptera*. A new phyletic tree of the latter is presented.

Le mâle d'*Ornithoptera allottei* a été décrit de Bougainville (Archipel des Salomons) par Rothschild en 1914 (p. 275). En 1916, Niepelt en a figuré les deux sexes (a: 20, pl. 17, fig. 1–2), alors que Peebless et Schmassmann, en 1917 (p. 426–427) en ont décrit la femelle en détail. Avec une courte note de Niepelt parue en 1916 (b: 31) et les considérations phylétiques de Zeuner (1943), c'est-là toute la littérature qui a été consacrée à cette espèce.[1]

A tort ou à raison, *Ornithoptera* (*Orn.*) *allottei* passe pour être l'espèce la plus rare du sous-genre et nous verrons dans les pages qui suivent qu'il présente un intérêt phylétique exceptionnel. J'ai eu récemment la bonne fortune d'en obtenir un ♂ provenant de Monoitu (Bougainville) et éclos en janvier 1969. Ce spécimen mesure 149 mm. d'envergure. Sur le dessus des ailes, la couleur métallique est bleu vert, assez terne, dans la moitié basale des ailes antérieures et la base et le centre des postérieures, alors que la moitié apicale de la bande radiale des antérieures et tout le pourtour externe des postérieures sont teintés d'un vert jaunâtre assez vif. Le dessous est uniformément vert franc. Malheureusement, à l'éclosion, l'aile antérieure gauche a été fortement endommagée et une abondante hémorragie a largement souillé les deux ailes antérieures. La figure 1 a donc été assez fortement retouchée. Je donne aussi un dessein des génitalia (fig. 8). Ceux de mon spécimen sont un peu différents de la figure 54 de Zeuner: les valves sont moins longues, la tête de la harpe non recourbée vers le bas et sa garniture d'épines hémicirculaire seulement.

Orn. allottei présente la particularité remarquable d'être "presque exactement intermédiaire" entre *priamus* Linné et *victoriae* Gray. Le Père

[1] On pourrait y ajouter quelques considérations parues dans "Yadoriga" (47, 1966: 19–20; 57, 1969: 4–6) sur les prix fabuleux atteints par cette espèce aux ventes de l'Hotel Drouot, des collections Le Moult et Rousseau-Decelle.



Fig. 1. *Ornithoptera allottei*, mâle, légèrement réduit.

Allotte qui l'a capturé le premier affirmait d'ailleurs à Rothschild qu'il avait découvert un hybride entre ces deux espèces. Mais l'auteur anglais publia une note (*in* Peebless et Schmassmann 1917: 427) réfutant cette opinion, à cause de l'existence de deux mâles identiques.

Pour commencer, nous allons examiner en détail les caractères extérieurs d'*allottei* en les comparant à ceux des sous-espèces les plus primitives de *priamus* et de *victoriae*, respectivement *priamus* Linné et *regis* Rothschild. Nous verrons que le nombre des caractères intermédiaires est étonnamment élevé et pourtant la liste qui suit est bien loin d'être complète. Il n'y a que quatre caractères communs avec *priamus*, 4, 23, 33 et peut-être 25. Avec *regis* il y en a neuf, 1, 2, 3, 5, 8, 9, 16, 22 et 26, alors que tous les autres, soient non moins de 28 sont intermédiaires.

La première impression qui se dégage d'une telle comparaison est que nous avons affaire à une série de trois espèces présentant des caractères graduellement accusés et spécialisés en une "orthogénèse" approximative. De tels cas sont d'ailleurs fréquents chez les Insectes et même la plupart d'entre eux comprennent en général un nombre plus grand d'unités. J'en connais une belle série de huit espèces chez les Trichoptères. Mais dans le cas qui nous occupe ici, c'est le nombre des caractères intermédiaires qui est étonnamment élevé.

Toutefois, il se pourrait que cette première impression, une série rectiligne de trois espèces graduellement spécialisées, soit fallacieuse et que la

TABLE 1. Caractères comparés des *Ornithoptera priamus, allottei* et *regis*.

	priamus	*allottei*	*regis*
Caractères du corps			
1) Bordure post-oculaire blanche	présente	absente	absente
2) Tache métallique du mésonotum	présente	absente	absente
3) Pilosité rouge des pleures	présente	absente	absente
4) Coloration de l'abdomen	jaune vif	jaune vif	blanc grisâtre
5) Bandes latérales noires des premiers segments	minces sur le premier segment	larges sur les deux premiers segments	larges sur les deux premiers segments
6) Faces latérales des segments III à V	uniformément jaunes	avec de petites taches noires	avec d'assez grandes taches noires
7) Face dorsale des tergites III à VII	uniformément jaune	avec une zone décolorée	avec une zone rosée
8) Pleurites abdominales	jaunes sauf les stigmates noirs	largement tachetées de noir	largement tachetées de noir
9) Bord apical du VIIIe tergite et bord supérieur des valves	étroitement noirs	largement noirs	largement noirs
Forme des ailes			
	priamus	*allottei*	*regis*
10) Ailes antérieures	en larges triangles rectangles	en triangles elliptiques, pas très larges	assez étroitement et régulièrement elliptiques
11) Ailes postérieures	subcirculaires, à peine plus longues que larges	1,5 fois plus longues que larges	2 fois plus longues que larges
12) Bord apical des ailes postérieures	fortement crénelé	faiblement crénelé	non crénelé
13) Echancrure de la cellule I	à peine indiquée	assez faible	très nette
14) Pilosité de l'aire anale	longue, brun clair	longue, beige	courte, blanchâtre
Coloration du dessus des ailes			
	priamus	*allottei*	*regis*
15) Bande radiale des antérieures	régulièrement étroite et continue	évanescente sur sa moitié basale, un peu élargie sur sa moitié apicale	présente à l'extrémité de l'aile seulement, où elle est très large
16) Bande cubitale	occasionnellement présente	absente	absente
17) Bande anale	régulièrement étroite et très longue	assez large à sa base où elle est unie à la bande radiale par un sablé métallique, puis interrompue et réduite à deux nuages intermédians	assez courte mais presque aussi large que l'aile
18) Coloration des ailes antérieures	verte, unicolore	légèrement bicolore, moitié basale vert-bleu, moitié apicale vert-jaune	nettement bicolore, verte et vert-or
19) Coloration des ailes postérieures	verte, unicolore	faiblement bicolore, vert-bleu au centre, vert-jaune au pourtour	fortement bicolore, verte au centre, avec une bande apicale dorée

TABLE 1. *Suite.*

	priamus	*allottei*	*regis*
Coloration du dessus des ailes			
20) Base des ailes postérieures	faiblement saupoudrée de noir	nettement sablée de noir	non noircie
21) Taches discales noires	grandes, circulaires	réduites et peu nettes occasionnellement absentes	exceptionnellement présentes, nettes ou non
22) Cellule I des postérieures	métallique	noire	noire
Coloration du dessous des ailes			
23) Taches discales noires des antérieures	en ligne régulière dans les cellules II à VIII	en ligne régulière dans les cellules II à VIII	en ligne irrégulière dans les cellules V à VIII
24) Taches discales noires des postérieures	six, grandes et nettes	six plus petites et nettes	1 à 4, exceptionnellement présentes nettes ou non
25) Taches submarginales dorées	assez souvent présentes	non signalées	presque toujours présentes
26) Bord noir des postérieures	fortement réduit	disparu	disparu
27) Taches marginales noires de l'apex des M et Cu	à peine indiquées	en assez grands triangles	en grands rectangles
28) Tornus	fortement jaune et noir	faiblement jaune	très faiblement jauni
29) Cellule et nervures qui en radient	nettement bordées de noir	cellule étroitement bordée de noir	cellule à peine bordée de noir
30) Coloration générale	non métallisée	faiblement métallisée	fortement métallisée
Nervulation			
	priamus	*allottei*	*regis*
31) Cellule des antérieures	ovale, plus de trois fois moins large que longue	aplatie à l'apex, 2,5 fois moins large que longue	presque cordiforme, deux fois moins large que longue
32) M3 et Cu des antérieures	longues et normalement espacées	plus courtes et un peu rapprochées	très courtes et rapprochées
33) Naissance de R3	de la périférie de la cellule	de la périférie de la cellule	de la base de R4 & 5
34) Croissant androconial	large, proche de la cellule	plus étroit, à mi-chemin entre la cellule et le bord	étroit, proche du bord de l'aile
35) Cellules des postérieures	3 fois plus longue que large	3,5 fois plus longue que large	4 fois plus longue que large
Génitalia			
	priamus	*allottei*	*regis*
36) Valves	subcirculaires	légèrement ovales	nettement ovales
37) Dents basales de la harpe	deux, peu marquées	une, assez grêle	une, effilée
38) Forme de la harpe	assez large	étroite	étirée
39) Col de la harpe	pas indiqué	peu marqué	bien net
40) Tête de la harpe	triangulaire, dirigée vers le haut	circulaire, dirigée vers l'arrière ou le bas	triangulaire, dirigée vers le bas
41) Position de l'armature d'épines	apicale	apicale et supérieure	circulaire

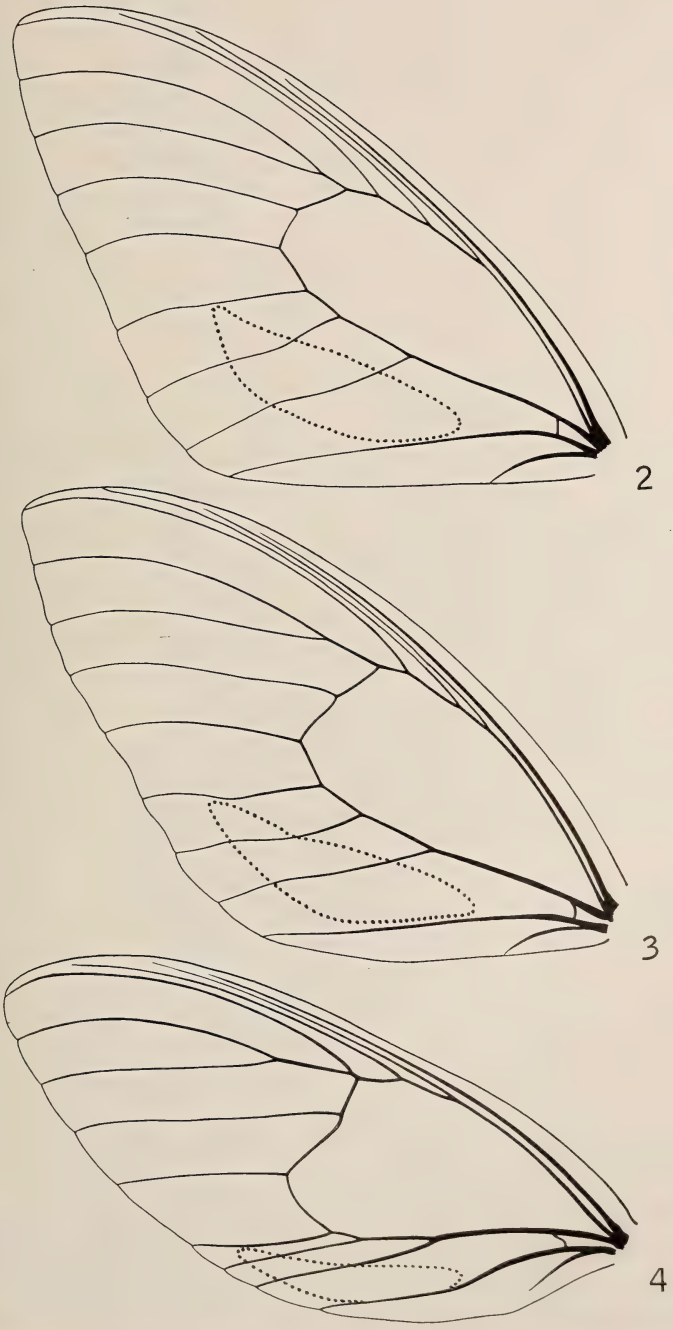
situation soit plus complexe. En effet, *allottei* montre aussi des caractères communs avec *croesus* Wallace, *alexandrae* Rothschild et les *Schoenbergia*, caractères que l'on ne trouve pas chez *priamus* et *regis*. Avec *croesus*, *allottei* montre des ailes antérieures en triangles assez elliptiques, à bord externe oblique et une bande anale très courte. Avec *alexandrae*, *allottei* présente une bande radiale étroite et nuageuse sur sa moitié basale et d'une couleur jaune-vert sur sa moitié apicale. La bande cubitale très courte et la bande radiale très étroite à sa base se retrouvent aussi chez l'ensemble des *Schoenbergia*. Ceci suggère qu'*allottei* pourrait être plus primitif que *priamus* et que *victoriae*.

Pour déterminer la position et le statut d'*allottei*, nous allons tenter de reconstituer l'évolution et la différenciation des espèces constituant le sous-genre *Ornithoptera*. Pour ce faire, nous passerons d'abord succinctement en revue les sous-genres *Troides*, *Trogonoptera* et *Schoenbergia*, qui sont plus primitifs qu'*Ornithoptera*. Cela nous permettra de nous faire une idée de ce qu'était l'ancêtre de ce sous-genre, qui à son tour nous servira de point de départ pour reconstituer la phylogénie de la lignée à laquelle il a donné naissance.

Une telle étude n'est pas la première qui ait été entreprise. En 1943, Zeuner (p. 147) a déjà analysé la phylogénie de ces lignées. Mais il s'est placé dans une perspective synchronique, c'est-à-dire statique, position aujourd'hui dépassée. L'auteur anglais a cité les caractères communs et les différences des diverses espèces, a évalué quantitativement leur importance relative et en a déduit l'ordre de différenciation des espèces, qu'il a exprimé en divisions arbitrairement quoique volontairement géométriques (Fig. 10). Nous allons essayer ici d'aller plus loin, en nous plaçant dans une perspective que la linguistique appelle diachronique. Nous ne verrons alors plus les caractères comme des structures seulement, mais comme des signes et les résultats d'évènements que nous tenterons de classer en séquences et en ordre successifs, d'où apparaitront plus clairement les parentés relatives des espèces. Nous verrons alors que, quoique les raisonnements de Zeuner soient corrects et convaincants, il y a lieu d'effectuer des changements à son arbre phylétique. Ne connaissant pas encore la femelle de plusieurs espèces, j'ai été réduit à utiliser les caractères du mâle seulement, ce qui diminue malheureusement la valeur des spéculations qui suivent.

→

Fig. 2, 3, 4. Nervulation des ailes antérieures de *Orn. priamus, allottei* et *regis* respectivement.


2
3
4

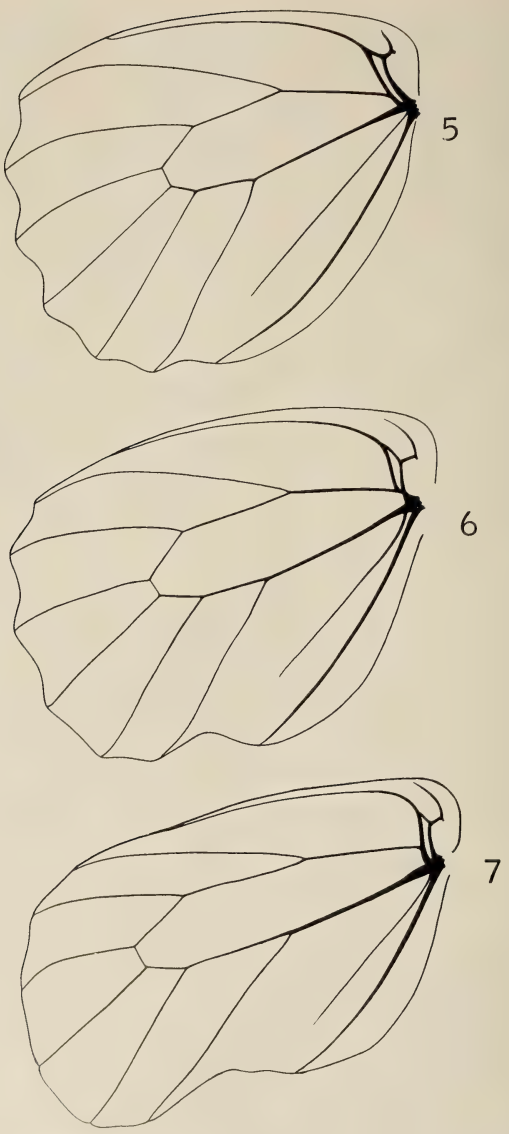


Fig. 5, 6, 7. Nervulation des ailes postérieures de *Orn. priamus, allottei* et *regis* respectivement.

Troides apparaît comme la lignée la plus primitive par beaucoup de caractères qui ont été indiqués par Zeuner. Nous n'en retiendrons que peu. Les ailes ont une coupe primitive. Les antérieures sont noires et zèbrées de longues lignes claires, nuageuses, situées dans les cellules et longeant les

nervures. Ces lignes soulignent simplement les nervures et leur ensemble ne forme pas de motifs. Les ailes postérieures sont largement jaunes translucides et montrent primitivement six taches discales noires. Les valve sont assez longuement ovales et la harpe bien allongée et avec une tête nettement indiquée.

Trogonoptera vient ensuite. Aux ailes antérieures, certaines des lignes claires du groupe précédent sont devenues vertes métalliques et sont groupées deux à deux pour former une série de dents triangulaires régulières, constituant un élégant motif submarginal se prolongeant en travers des ailes postérieures qui ont entièrement perdu les écailles jaunes translucides. Les antérieures ont acquis une forme très allongée, spécialisation propre à cette lignée. Les génitalia ne nous seront guère utiles, car ils sont spécialisés dans une direction très particulière: les valves sont plus hautes que longues et la harpe en rectangle concave dirigé vers le bas.

Parmis les *Schoenbergia, goliath* Oberthür apparaît comme l'espèce la plus archaïque par l'extension maximale de la zone jaune des ailes postérieures. La forme des ailes est primitive. La coloration des antérieures s'est enrichie et consiste en une bande radiale, apparue soudainement, continue, mais très mince à sa base et une large zone cubitale et anale en triangle rectangle. La première bande dérive certainement de la série de lignes claires que certains *Troides* et *Trogonoptera* possédent contre le bord costal, au niveau de l'extrémité de la cellule. C'est pourquoi elle est primitivement plus large à cet endroit que plus antérieurement. Son bord interne profondément incisé de noir dans les cellules montre clairement que la zone cubito-anale dérive, par élargissement et coalescence, d'une série de triangles submarginaux homologues de ceux des *Trogonoptera.* La cellule I des ailes postérieures est noire.

Les autres *Schoenbergia* montrent une spécialisation en commun: la large zone cubito-anale est maintenant plus ou moins complètement scindée en deux, ce qui fait que les ailes antérieures sont ornées de trois bandes longitudinales: une radiale, complète mais toujours fine ou évanescente à sa base, une cubitale en large triangle aux deux extrémités effilées et une anale courte et étroite. Les ailes postérieures ont l'aire jaune un peu réduite mais encore importante et la cellule I reste constamment noire. Les valves sont assez longuement ovales, caractère primitif et forment en général deux pointes apicales inférieures, structure spécialisée. La harpe est longue et mince, particularité primitive, mais étalée à sa base et très grêle à son extrémité, deux indices de spécialisation. A sa base, elle est accompagnée de deux dents, structure primitive, qui sont devenues grêles et barbelées par spécialisation.

Zeuner indique que la seule différence constante entre les *Schoenbergia*



Fig. 8. Valve et harpe de *Orn. allottei.*

et les *Ornithoptera* est la présence, chez ces derniers, d'un croissant androconial aux ailes antérieures. Je puis donc en ajouter un second, d'ailleurs lié au premier: *Schoenbergia* possède une bande cubitale triangulaire, beaucoup plus large que les deux autres et bien distincte, sauf chez *goliath* chez qui elle est encore fusionnée à la bande anale. Chez *Ornithoptera*, en conséquence de l'acquisition du croissant androconial, la bande cubitale est primitivement linéaire ou secondairement perdue. Des ailes antérieures trifasciées sont donc un caractère primitif pour *Schoenbergia* et *Ornithoptera.* Il est remarquable que nous puissions suivre les changements progressifs et continus de la coloration des ailes antérieures depuis *Troides* jusque, nous le verrons à nouveau plus bas, chez *priamus* et *victoriae* problème que n'a pas pu résoudre Zeuner (p. 134).

Ceci étant posé, nous avons suffisamment d'éléments pour reconstituer les caractères de l'ancêtre théorique d'*Ornithoptera* et en déduire la différenciation des espèces selon le tableau des pages qui précèdent.

L'*Ornithoptera* ancestral théorique (1, fig. 9) possède une bande postoculaire blanche et de la pilosité rouge sur les pleures thoraciques. Il est probablement dépourvu de bande métallique sur le mésonotum, car cette dernière n'est présente que chez *croesus* et *priamus*, *Ornithoptera* moyennement spécialisés et chez *paradisea* et *meridionalis* qui sont les deux *Schoenbergia* les plus évolués. Ceci indique une spécialisation par convergence. L'abdomen est jaune vif, assez largement teinté de noir latéralement à sa base et sur les pleurites et probablement dépourvu de tache dorsale sur les segments III et IV. Le bord apical du VIIIe tergite et le bord supérieur des valves sont largement bordés de noir.

Les ailes antérieures sont triangulaires et anguleuses et les postérieures subcirculaires, avec leur bord apical crénelé et nettement échancré dans la cellule I. La frange anale est longue.

La coloration du dessus des ailes antérieures est du même type trifascié que celle des *Schoenbergia*. Mais, à cause du croissant androconial qui s'étend en travers des cellules 2, 3 et 4, la bande cubitale est réduite à un mince liseré longeant le bord de la cellule et envoyant peut-être des prolongements le long de la base des nervures médianes et cubitales, comme chez l'*hecuba* actuel. La bande radiale est étroite et très fine ou absente à la base et la bande anale étroite et très courte. La coloration est uniformément verte.

Le dessus des ailes postérieures est toujours largement jaune translucide dans sa partie antérieure, avec quelques taches submarginales concolores et 5 taches discales noires. La couleur métallique est verte, mais la cellule I est noire et la base de l'aile peut être sablée de noir.

Les dessins du dessous des ailes sont probablement fort semblables à ceux de la ♀ de *lydius*. Les antérieures montrent une bordure marginale noire assez large et une série de taches discales confluentes en une ligne assez régulière au milieu des cellules 2 à 8. Aux ailes postérieures, le bord est également margé de noir, les taches discales grandes, rondes et au nombre de six, le tornus teinté de jaune et peut-être de noir et la cellule et les nervures médianes et cubitales bordées de noir. L'ensemble des deux ailes n'est pas métallisé.

La cellule des ailes antérieures est relativement large, c'est-à-dire environ 2,5 fois moins large que longue alors qu'aux ailes postérieures, elle est au moins 3,5 plus longue que large.

Les valves sont légèrement ovales, la harpe assez grêle et bien allongée, avec un col et une tète faiblement indiqués et des épines en position apicale. Il y a deux dents basales assez longuement triangulaires.

Cet ancêtre paraît avoir donné naissance à deux formes représentant le début de deux directions d'évolution différentes: la lignée de *croesus* contenant ce dernier, *aesacus* et *priamus* et la lignée d'*allottei*, comprenant en outre celui-ci, *victoriae* et *alexandrae*.

L'ancêtre théorique 2 (fig. 9), progéniteur de la lignée de *croesus* a assez peu changé extérieurement, mais acquis de nombreuses spécialisations de détail. Le mésonotum est orné d'une bande métallique verte longitudinale. Aux ailes antérieures, la bande radiale s'est un peu renforcée: elle est étroite mais bien régulière dès sa base. La bande cubitale est présente mais linéaire et la bande anale toujours courte. Les ailes postérieures sont comme celles de l'ancêtre I, avec l'aire jaune translucide réduite et localisée à la moitié antérieure de l'aile, mais elles ont acquis une



Fig. 9. Arbre phylétique du sous-genre *Ornithoptera*. La divergence relative des tiges indique les directions différencielles d'évolution. Les niveaux où se situent les espèces signifient très approximativement les degrés relatifs de spécialisation de ces dernières.

importante spécialisation, la cellule I est entièrement métallique en-dessus. La nervulation reste inchangée, avec la cellule des ailes antérieures assez large et celle des postérieures plutôt courte. Les génitalia, par contre, sont assez modifiés: les valves sont subcirculaires, la harpe courte, assez massive, en forme de parallélogramme, avec un col et une tête à peine marqués. Les deux épines basales sont très peu proéminentes.

Cet ancêtre 2 a donné naissance aux trois espèces actuelles *croesus*, *aesacus* et *priamus*, occupant des seuils de spécialisation fort inégaux. *Croesus* n'a acquis que peu de particularités nouvelles, mais ces dernières sont telles que l'aspect de l'insecte a beaucoup changé. Les ailes antérieures se sont étirées vers l'extérieur en triangles assez obliques. La bande radiale s'est considérablement élargie, la bande cubitale a entièrement disparu, alors que la bande anale a conservé son aspect primitif et reste courte, sauf chez certains individus chez qui elle se prolonge en une traînée sablée jusqu'à M1 (*lydius berchmansii* vd. Bergh). Le caractère le plus frappant est que la lumière interférencielle primitivement bleue des aires métalliques, qui se combine avec le pigment jaune sous-jacent pour donner une couleur apparante verte, a viré au rouge et produit ce flamboiement orange qui a tant ému Wallace et valu son nom à l'espèce. Par conséquence, l'abdomen qui était primitivement jaune, a aussi viré à l'orange. Seule la bande du mésonotum reste verte.

Priamus est considérablement spécialisé et a acquis une série de particularités qui pourraient faire figure de caractères primitifs comparés à ceux d'*allottei* et de *victoriae*, mais qui sont en réalité des spécialisations dans une direction d'évolution opposée. Les zones noires de la base de l'abdomen, des pleurites, du VIIIe tergite et des valves sont nettement réduites. Les ailes antérieures sont en triangles rectangles, caractère primitif, mais le bord apical des postérieures est fortement crénelé. Sur le dessus, les bandes radiale et cubitale sont inchangées, mais la bande anale se prolonge de façon continue tout le long du bord anal, jusqu'à l'apex de l'aile devenant remarquablement symétrique de la bande radiale, spécialisation importante qu'on ne trouve que chez *priamus* et *aesacus*. Les ailes postérieures ont perdu la large zone jaune translucide, mais en ont retenu des traces, inconstamment présentes, sous forme de petites taches submarginales, dans l'aire sous-costale et les cellules III à VI. Les spécimens possédant ces taches ont reçu des noms variés: *triton* Felder chez *poseidon*, *flavomaculata* Przegendza et Ribbe chez *hecuba* et *urvilleanus* respectivement et *flavopunctata* Rousseau-Decelle chez *caelestis*. La base de l'aile postérieure a tendance à se sabler de noir. Les dessins du dessous des ailes sont inchangés, de même que les génitalia. Enfin, la cellule des

ailes antérieures est nettement rétrécie et celle des postérieures raccourcie, spécialisation exclusive à *priamus*.

La différenciation des nombreuses sous-espèces de *priamus* a été bien étudiée par Zeuner (p. 138, 148). Je n'y reviens donc pas ici.

Il m'est difficile d'assigner une place précise à *aesacus*, car il m'est resté inconnu. Je puise donc les renseignements qui suivent chez Zeuner (p. 137, 149). *Aesacus* s'est probablement différencié d'une forme voisine de *croesus* et occupe un seuil de spécialisation moins élevé que *priamus*, ce qu'indiquent clairement la cellule des ailes antérieures restée large et celle des postérieures toujours longue, comme chez *croesus*. La bande radiale des antérieures est large quoique moins que chez *croesus* et la bande anale très longue comme chez *priamus*. Aux ailes postérieures, la cellule I est métallisée. La coloration générale est bleu verte. Les valves sont subcirculaires et les dents basales de la harpe sont réduites, mais celle-ci est amincie à son extrémité et avec une armature spineuse apicale subcirculaire comme dans la lignée d'*allottei*.

L'ancêtre théorique 3 de la lignée d'*allottei* (Fig. 9) montre peu de spécialisations fondamentales à partir de l'ancêtre I, mais de nombreux changements de détail. Les bandes post-oculaires blanches sont perdues, mais la pilosité rouge des pleures thoraciques est conservée. L'abdomen est toujours jaune vif avec les zones noires basales et latérales bien développées et sur les segments 3 et 4 apparaît une ligne décolorée. Les ailes antérieures sont en triangles obliques comme chez *croesus*, avec leur angle apical postérieur arrondi. Les postérieures s'allongent légèrement et l'échancrure de la cellule I s'approfondit. La coloration des antérieures est primitive, avec la bande radiale très mince à la base de l'aile, la bande cubitale toujours présente mais vestigiale et la bande anale courte. Aux ailes postérieures, la coloration du dessus a changé dans le même sens que celle de *priamus* et ressemble beaucoup à celle de ce dernier. La zone basale, jaune translucide a entièrement disparu, mais les point submarginaux de la même couleur sont retenus. La cellule I est toujours noire. Aux deux ailes, la coloration bipartite apparaît: à la partie apicale, le vert se teinte nettement de jaune. En dessous, la bordure marginale noire se réduit, mais le noir a tendance à remonter l'extrémité des nervures. Les taches discales sont légèrement réduites et la couleur de fond se métallise. La nervulation est primitive, de même que les génitalia.

Allottei montre des changements assez nombreux mais légers à partir de l'ancêtre 3. Il est plus proche de ce dernier que *croesus* l'est de son ancêtre 2. La pilosité thoracique rouge est maintenant perdue. Les ailes antérieures se sont rétrécies et arrondies, alors que les postérieures se sont un peu allongées. La bande radiale des ailes antérieures est évanescente sur toute

sa moitié basale, comme c'est parallèlement les cas chez *chimaera* et *tithonus*. La bande anale est nettement élargie et se prolonge en un sablé jusqu'au bord costal. Les taches discales des ailes postérieures sont réduites en nombre et de taille. Mais surtout la couleur métallique du dessus des deux ailes est maintenant nettement bipartite: aux antérieures, l'apex de la bande radiale et aux postérieures le pourtour de l'aile sont vert-jaune assez brillant. Sous les deux ailes, les dessins sont toujours d'un type nettement primitif, sauf que le long du bord des postérieures le noir forme de nets triangles à l'apex des nervures et la couleur générale se métallise. Aux antérieures, la cellule a continué de s'élargir alors qu'elle s'est encore allongée aux postérieures. Les génitalia sont peu changés sauf qu'une des dents basales de la harpe a disparu, alors que l'autre s'est un peu allongée.

Victoriae est une espèce très remarquable, qui représente l'aboutissement de l'évolution de la lignée d'*allottei*, et, comme telle, occupe un palier de spécialisation nettement plus élevé que *priamus*. Elle apparaît très spécialisée par tous ses caractères et cela dans la même direction d'évolution qu'*allottei*. Ceci indique qu'elle est issue soit de ce dernier soit d'un ancêtre extrêmement semblable à celui-ci. *Victoriae* et *allottei* représentent donc deux étapes d'une spécialisation linéaire. J'ai noté non moins de 28 caractères qui sont moyennement spécialisés chez le premier et très accentués chez le second. Ce sont: 6, 7, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 24, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 40 et 41. Comme ils sont cités dans la table qui précède, je ne les énumérerai pas une seconde fois, mais commenterai un petit nombre des plus intéressants. Les plus frappants sont évidemment l'élongation et l'arrondissement de la forme des deux ailes et l'exagération des proportions des deux cellules. Le plus intéressant est certainement la forte modification du développement des bandes métalliques des ailes antérieures. La bande radiale n'est pas interrompue en son milieu comme il pourrait le sembler et comme Zeuner l'a cru (p. 139). Mais une comparaison avec *allottei* et les divers *Schoenbergia* montre que cette bande s'est retirée, comme en une sorte de mouvement amoebien, de presque toute la longueur de l'aile et qu'elle s'est groupée et considérablement élargie à son extrémité pour former un triangle doré remplissant l'intérieur de la partie apicale de l'aile. La bande anale s'est considérablement développée, non en longueur comme chez *priamus*, mais en largeur et occupe toute la base de l'aile, atteignant l'aire radiale où elle a pris la place de la bande de ce nom. La bande cubitale, qui a été perdue par *allottei* déjà, n'est pas comprise dans cette large aire basale.

Notons aussi que les taches submarginales jaunes translucides, jamais

signalées chez *allottei*, sont presque toujours présentes chez *victoriae* et atteignent parfois une taille considérable. Si, chez *allottei*, tout le pourtour de l'aile postérieure est vert jaune, chez *victoriae*, seul l'apex est doré et il peut être très brillant.

Certaines des variations intra-subspécifiques de *victoriae* sont intéressantes, car elles se font dans une direction opposée à celle de leurs homologues de *priamus*. Chez ce dernier, les taches discales noires et les points jaunes submarginaux du dessus des ailes postérieures décroissent de taille d'avant en arrière et, lorsque le centre de l'aile est poudré de noir, c'est à la base de l'aile qu'il l'est le plus fortement. Chez *victoriae*, le gradient d'évanescence a renversé sa direction: c'est près du tornus que les taches noires et jaunes sont les plus développées et elles décroissent en direction de l'avant. De même, lorsque la surface s'ennuage de noir, c'est à partir de la bande dorée apicale.

Je ne crois pas inutile d'ajouter quelques commentaires sur les différentes sous-espèces et aberrations de *victoriae*. Les sous-espèces décrites jusqu'ici sont les suivantes:

regis Rothschild, de Bougainville.
isabellae Rothschild, de Santa Isabel.
reginae Salvin, de Malaita
victoriae Gray, de Guadalcanal, Tulagi et Florida.
rubianus Rothschild, de Rubiana et Kolombangara.
resplendens Ehrmann, de Choiseul.

La description d'une septième sous-espèce récemment découverte à San Cristobal est annoncée.

A mon avis, *resplendens* est certainement synonyme de *regis* comme c'est probablement le cas d'*isabellae*. Des quatre espèces bien connues *regis* et *victoriae* sont certainement les plus primitives, ce qu'indiquent le maximum d'extension de la couleur métallique sur le dessus des deux ailes et les deux couleurs vert et or bien contrastées. *Victoriae* toutefois montre une réduction en longueur de la bande radiale, ce qui est une légère spécialisation par rapport à *regis*. Ces deux sous-espèces sont extrêmement variables, surtout *regis* et cela aussi bien par les couleurs que par les les dessins. J'ai vu des spécimens dont le dessus des deux ailes est d'un vert uniforme, acide et agressif. Chez certains autres, la bande apicale des ailes postérieures a le brillant lumineux de l'or en fusion ou l'éclat adouci du vieil or patiné ou même la nuance rougeâtre du cuivre oxydé. Chez quelques exemplaires, le centre des ailes postérieures peut être d'un bleu ciel très clair. De nombreux spécimens de chacun des deux *regis* et *victoriae* présentent les caractères de l'autre, ce qui fait que ces dernières ne sont guère identifiables que statistiquement.

Il n'est pas impossible que *regis* aussi ne soit pas valide et ne soit qu'une simple race de *victoriae*. *Reginae* est nettement plus spécialisé que les deux précédents, par ses ailes postérieures largement envahies de noir à partir de la bande dorée, qui est elle-même réduite. *Rubianus* enfin est la forme de fin de lignée et la plus modifiée par sa coloration appauvrie. La bande radiale des ailes antérieures est fortement réduite de taille dans sa partie antérieure, ce qui fait qu'elle se trouve maintenant au milieu de la largeur de l'aile et elle est retournée au vert primitif. La bande apicale dorée des ailes postérieures de même que les points jaunes submarginaux sont perdus.

Il est intéressant de noter que, comme chez *priamus*, les mêmes variations sont visibles chez chacune des sous-espèces: la couleur noire peut envahir plus ou moins largement les ailes postérieures, le vert et l'or sont plus ou moins contrastés et les deux bandes des ailes antérieures peuvent être réunies par un sablé métallique.

Un certain nombre de formes individuelles ont été décrites. *Buinensis* Le Moult et *infanta* Bryk et Peebless désignent tous deux des *regis* dont les deux bandes des ailes antérieures sont réunies. *Sanguinea* Rousseau-Decelle, *brabanti* Le Moult et *gabrielli* Le Moult s'appliquent à des *regis* dont certaines régions des deux ailes, en général les aires dorées, portent "une surcharge rouge-brun, couleur de sang séché". Cette couleur a également été signalée chez *chimaera draceana* ab. *sanguifluens* Rousseau-Decelle. J'ai moi-même vu des *regis* pourvus de zones rougeâtres, variables en intensité et en extension, parfois réduites à de petites taches irrégulières et asymétriques aux deux ailes. Ces irrégularités pourraient indiquer une malformation ou une affection pathologique des écailles métalliques. *Alexisi* Le Moult désigne des *regis* dont le vert a entièrement tourné au doré sur les deux faces des deux ailes. *Lanieli* Le Moult, enfin, est intéressant car il définit des *regis* qui ont retenu sur ou sous les ailes postérieures de deux à quatre taches discales noires, homologues de celles de *priamus* et *allottei*.

Reste à placer la troisième et dernière espèce de la lignée d'*allottei*, *alexandrae*. Cette forme étant célèbre et ses caractères bien connus, il me paraît inutile de m'y attarder longuement. Elle est vraisemblablement issue de l'ancêtre 3 et non d'une forme voisine d'*allottei*, car elle a conservé quelques caractères primitifs perdus par ce dernier, comme la pilosité thoracique rouge, une bande cubitale vestigiale et les deux dents de la base de la harpe. Elle possède aussi quelques particularités en commun avec *allottei*, comme la bande radiale des ailes antérieures nuageuse à sa base et vert-jaune à son extrémité, les proportions des cellules des deux ailes et l'abdomen resté jaune vif. Avec *victoriae* elle montre en commun

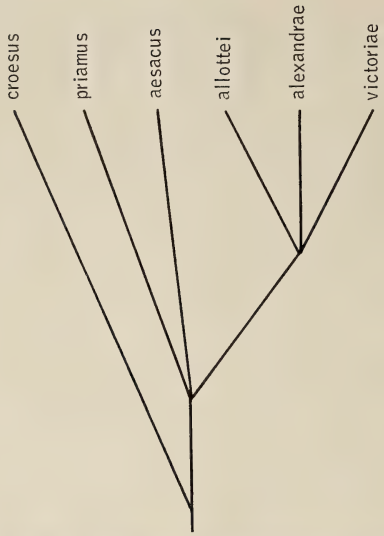


Fig. 10. Arbre phylétique du sous-genre *Ornithoptera* d'après Zeuner.

la forme longuement elliptique des ailes et la courte frange anale blanchâtre. Mais *alexandrae* a développé un bon nombre de caractères de son crû et des plus importants, ce qui montre qu'elle s'est très fortement différenciée de l'ancêtre 3 dans une direction particulière. Citons le gigantisme, la perte presque complète du pigment jaune sur les deux ailes, la bande anale élargie, très allongée et englobant le croissant androconial, les dessins très particuliers des ailes postérieures, dont la cellule I est colorée comme dans la lignée de *priamus* et la perte de toutes les taches discales sous les deux ailes. Le dessous des ailes est très largement coloré et l'une des dents basales de la harpe est barbelée, caractères acquis par convergence avec les *Schoenbergia*.

Nous référant à nouveau à l'arbre phylétique de Zeuner (Fig. 10), nous voyons maintenant les changements qui s'imposent. Cet auteur a reconnu l'existence des deux lignées du sous-genre, celle de *priamus* et celle d'*allottei*. Pourtant, il indique que *croesus* s'est différencié le premier du tronc de l'arbre, avant l'apparition des deux lignées. Ensuite seraient apparu simultanément *priamus*, *aesacus* et l'ancêtre de la lignée d'*allottei* qui à son tour aurait produit simultanément *allottei*, *alexandrae* et *victoriae*.

En réalité, il semble assez évident que l'ancêtre du sous-genre a donné naissance d'abord aux deux ancêtres 2 et 3, à partir desquels se sont différenciées les deux lignées. *Croesus* semble en effet être apparu le premier dans la lignée de *priamus*, mais dans celle d'*allottei*, il est probable qu'*alexandrae* se soit différencié avant *allottei*.

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STUDIES ON THE *CATOCALA* (NOCTUIDAE) OF SOUTHERN NEW ENGLAND. I. ABUNDANCE AND SEASONAL OCCURRENCE OF THE SPECIES, 1961–1969

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The *Catocala* moths pose an interesting evolutionary enigma. This large genus, consisting of some 200 species in the broadest use of the generic name, is characterized by extensive sympatry throughout most North Temperate regions of the world, and its members occupy a relatively narrow ecological niche, the larvae being oligophagous and the adults being cryptically marked when at rest on tree trunks. In New England alone, at least 52 *Catocala* species are known to occur (Forbes 1954), and we have taken as many as 21 species on a single night at one location.[1] Nevertheless, natural hybrids are unknown. This tremendous array of sympatric and rather closely related species immediately raises the question as to what sorts of mechanisms operate to limit natural hybridization within the genus. One long-range goal of these studies is to describe such mechanisms through detailed analyses of the behavior, ecology, and genetics of these moths.

Despite the popularity of the North American *Catocala* moths with collectors, relatively little of their total biology is known. They have been treated taxonomically by Grote (1872, 1873, 1876), Hulst (1880,

[1] 20 August 1961, Washington, Connecticut: *C. epione, antinympha, badia, habilis, flebilis, obscura, residua, retecta, dejecta, palaeogama, subnata, neogama, ilia, parta, concumbens, sordida, andromedae, ultronia, grynea, praeclara,* and *amica.*

1884), Hampson (1910), McDunnough (1938), and Forbes (1954). Plates depicting most of the North American species are available in Holland (1903) and Barnes and McDunnough (1918). Present knowledge of the life histories and geographic ranges of the New England *Catocala* is summarized in Forbes (1954).

Information on the behavior and ecology of these moths is scanty and largely anecdotal. Some observations on the resting habits of adults have been recorded (e. g. Bunker, 1874; French, 1880; Johnson, 1882; Rowley and Berry, 1909; Kettlewell, 1958; Sargent and Keiper, 1969). Limited data on the movements of adults have been obtained from studies of color-marked individuals (Brower, 1930). Virtually nothing is known of courtship and mating behaviors—a fact that has precluded any detailed studies on the genetics of these moths.

The present report constitutes a first step in our study of the *Catocala* of southern New England: an account of the species that are present, based on daily counts of adults taken for several years in two localities. It is hoped that these data will provide a foundation for planning further investigations, will serve as a record for future comparative purposes, and will stimulate others to obtain comparable data from their localities.

Methods

The basic data utilized in this report are daily counts of adult *Catocala* taken in the vicinity of Amherst, Massachusetts (Area 1) for the years 1964 through 1969; and from Washington, Connecticut (Area 2) for the years 1961 through 1965, 1967, and 1969.

Area 1. Records here are based on collecting of 2009 specimens by T. D. Sargent and two graduate students at several localities in Franklin and Hampshire Counties in north-central Massachusetts, all localities lying within 10 miles of the center of Amherst. The vast majority of the records are from two sites, one in Pelham (1964–66) and another in Leverett (1967–69). *Catocala* taken at bait, a brown sugar-beer mixture painted onto tree trunks, comprise 84% of the records from this area, whereas *Catocala* taken at lights (several 150-watt incandescent bulbs, and one 15-watt black light fluorescent tube) comprise 12% of the records. The additional 4% of the records are based on the finding of resting moths in nature. *Catocala* were recorded on a daily basis from 1 July to 1 September (except for occasional 1 to 2 day absences, or days of extremely inclement weather), and more sporadically from 1 September to 1 November each year.

Area 2. Records here are based on collecting of 5806 specimens by S. A. Hessel at one site in Washington, Litchfield County, in west-central

Connecticut; this site lies approximately 65 air-miles to the southwest of Amherst, Massachusetts.[2] All records of *Catocala* from this area are based on specimens taken at lights, most at one Robinson mercury vapor light-trap, and some at one 15-watt black light fluorescent tube. These lights were in operation from mid-March to mid-November each year (except for occasional 1 to 3 day absences).

Several important differences in collecting procedures between the two areas should be stressed:

(1) Captures in Area 1 were predominantly at bait; captures in Area 2 were exclusively at lights.

(2) Collecting in Area 1 was generally terminated by midnight; in Area 2 the Robinson trap was operating continuously from dusk to dawn.

(3) Several collecting sites are included in Area 1; Area 2 includes only one collecting site.

(4) Collecting in Area 1 was sporadic after September 1, but continued unabated in Area 2.

Because of these differences, the records for the two areas will be presented separately.

It should also be noted that some *Catocala* individuals may have been recorded on more than one occasion, as the majority of specimens in both areas were released after examination. However, studies of color-marked *Catocala* in Area 1 (Sargent, in prep.) indicate that very few individuals are captured on more than one occasion.

The species of *Catocala* were identified as keyed and described in Forbes (1954), and the species names used throughout this report are from that source. It should finally be noted that specific distinctions were not always made between *gracilis* and *sordida* in both areas, and among *crataegi*, *blandula*, and *mira* in Area 1. It is known from mounted specimens, however, that all of these species occurred in both areas.

In area 1, the sex of *Catocala* specimens was determined, and the precise time of their capture noted. These data are not included in the present report, but will be treated in subsequent papers.

Results and Discussion

Abundance. The *Catocala* taken each year in Areas 1 and 2 are enumer-

[2] This site lies at the bottom of a very narrow north-south valley through which an all-season stream flows southward. The lower end of the valley, only one mile distant, opens onto terrain which rolls gently southward to the Connecticut coast, while northward, the Litchfield Hills, of which it is part, become the Berkshires of Massachusetts. The surrounding hills are largely mixed deciduous woodlands, but include several seral stages resulting from the abandonment of farms, pastures, and woodlots of the Colonial period. Climatically, as demonstrated by meteorological maps, the site is to be included with territory considerably more northern than with the Connecticut and Hudson River valleys of its latitude.

TABLE 1. *Catocala* spp. recorded in the Amherst, Mass. area, 1964–69.

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)						Totals and Percent of Grand Total for Entire Period
	1964	1965	1966	1967	1968	1969	
ilia	12	49	20	47	206	346	680
	(22)	(25)	(7)	(13)	(58)	(46)	(34)
ultronia	7	49	115	25	49	79	324
	(13)	(25)	(39)	(7)	(14)	(11)	(16)
crataegi et al.*	2	14	47	5	36	5	109
	(4)	(7)	(16)	(1)	(10)	(1)	(5)
retecta	–	3	11	30	5	58	107
		(2)	(4)	(8)	(1)	(8)	(5)
antinympha	1	1	15	57	11	19	104
	(2)	(1)	(5)	(16)	(3)	(3)	(5)
gracilis &	6	2	11	57	5	10	91
sordida	(11)	(1)	(4)	(16)	(1)	(1)	(5)
cara	1	–	13	2	3	60	79
	(2)		(4)	(1)	(1)	(8)	(4)
concumbens	3	5	19	14	6	29	76
	(5)	(3)	(6)	(4)	(2)	(4)	(4)
relicta	–	21	5	11	3	11	51
		(11)	(2)	(3)	(1)	(1)	(3)
grynea	2	18	10	7	3	10	50
	(4)	(9)	(3)	(2)	(1)	(1)	(2)
amica	3	4	4	30	3	6	50
	(5)	(2)	(1)	(8)	(1)	(1)	(2)
amatrix	–	–	–	–	–	36	36
						(5)	(2)
unijuga	3	3	5	6	6	10	33
	(5)	(2)	(2)	(2)	(2)	(1)	(2)
micronympha	2	4	2	22	–	3	33
	(4)	(2)	(1)	(6)			(2)
epione	1	1	–	6	8	16	32
	(2)	(1)		(2)	(2)	(2)	(2)
andromedae	2	2	3	15	4	4	30
	(4)	(1)	(1)	(4)	(1)	(1)	(1)
praeclara	5	7	6	5	2	4	29
	(9)	(4)	(2)	(1)	(1)	(1)	(1)
similis	4	6	–	11	–	–	21
	(7)	(3)		(3)			(1)
cerogama	–	–	2	3	1	7	13
			(1)	(1)		(1)	(1)
residua	–	–	–	–	–	11	11
						(1)	(1)
palaeogama	–	–	1	–	1	9	11
						(1)	(1)
neogama	–	–	1	3	1	5	10
				(1)		(1)	

TABLE 1. *Continued.*

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)						Totals and Percent of Grand Total for Entire Period
	1964	1965	1966	1967	1968	1969	
habilis	–	–	–	5 (1)	–	3	8
coccinata	–	1 (1)	–	5 (1)	1	1	8
obscura	1 (2)	3 (2)	1	–	–	1	6
briseis	–	1 (1)	2 (1)	–	–	–	3
innubens	–	1 (1)	–	–	–	–	1
piatrix	–	–	1	–	–	–	1
dejecta	–	–	–	–	–	1	1
parta	–	–	–	–	–	1	1
No. Species	16	20	21	21	19	26	33
No. Individuals	55	195	294	366	354	745	2009

* records of *blandula* and *mira* included here

ated in Tables 1 and 2 respectively. In both cases, the species are listed in a descending order of overall abundance. Examination of these tables reveals some differences between results from the two areas. *Catocala* numbers, in terms of both species and individuals, are greater from Area 2. In part, this difference must be due to the longer daily and seasonal collecting periods in Area 2, and perhaps to a greater efficiency of the Robinson trap, when compared to bait, as a collecting device. However, further consideration indicates that those species that are markedly more abundant in Area 2 are almost invariably hickory and walnut (Juglandaceae) feeders. Accordingly, the data were reanalysed with reference to the known foodplants of the various *Catocala* species (Forbes, 1954), and this procedure revealed that remarkably more hickory-walnut feeders, both in terms of species and individuals, were taken in Area 2 (Table 3).

This disparity in records of feeders on the Juglandaceae seems to reflect something more than the previously listed differences in collecting procedures between the two areas. It seems more likely that differences in the frequency of hickories and walnuts are important. In this regard, the presence of Butternut (*Juglans cinerea* L.) as a common tree in the woodlands near the collecting site in Washington, and its virtual absence in all collecting areas near Amherst, seems most suggestive. It could be that

TABLE 2. *Catocala* spp. recorded in Washington, Conn., 1961–65, –67, –69.

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)							Totals and Percent of Grand Total for Entire Period
	1961	1962	1963	1964	1965	1967	1969	
palaeogama	194	487	12	40	33	81	48	895
	(15)	(34)	(4)	(8)	(6)	(7)	(8)	(15)
residua	216	345	45	53	54	135	39	887
	(17)	(24)	(15)	(10)	(10)	(12)	(7)	(15)
habilis	121	79	63	119	78	159	34	653
	(9)	(6)	(21)	(22)	(14)	(14)	(6)	(11)
amica	85	78	10	27	27	89	50	366
	(7)	(6)	(3)	(5)	(5)	(8)	(9)	(6)
antinympha	52	26	13	13	16	182	27	329
	(4)	(2)	(4)	(2)	(3)	(16)	(5)	(6)
neogama	97	36	23	38	39	68	28	329
	(8)	(3)	(8)	(7)	(7)	(6)	(5)	(6)
concumbens	14	12	21	59	68	75	60	309
	(1)	(1)	(7)	(11)	(12)	(6)	(10)	(6)
retecta	83	55	19	29	34	55	19	294
	(7)	(4)	(6)	(5)	(6)	(5)	(3)	(5)
grynea	72	30	8	19	35	39	56	259
	(6)	(2)	(3)	(4)	(6)	(3)	(10)	(4)
ultronia	41	38	14	24	32	45	37	231
	(3)	(3)	(5)	(5)	(6)	(4)	(6)	(4)
epione	69	37	14	6	19	24	15	184
	(5)	(3)	(5)	(1)	(3)	(2)	(3)	(3)
andromedae	40	30	7	8	26	10	18	139
	(3)	(2)	(2)	(1)	(5)	(1)	(3)	(2)
obscura	27	17	3	17	9	26	25	124
	(2)	(1)	(1)	(3)	(2)	(2)	(4)	(2)
micronympha	38	43	5	11	4	6	15	122
	(3)	(3)	(2)	(2)	(1)	(1)	(3)	(2)
serena	3	–	–	8	12	52	28	103
				(1)	(2)	(5)	(5)	(2)
gracilis & *sordida*	16	7	12	15	10	7	8	75
	(1)		(4)	(3)	(2)	(1)	(1)	(1)
mira	4	14	8	11	9	2	20	68
		(1)	(3)	(2)	(2)		(3)	(1)
badia	9	7	3	2	8	21	7	57
	(1)		(1)		(1)	(2)	(1)	(1)
cara	15	12	3	6	2	5	4	47
	(1)	(1)	(1)	(1)			(1)	(1)
dejecta	10	7	1	2	3	15	1	39
	(1)				(1)	(1)		(1)

TABLE 2. *Continued.*

Species	Numbers of Individuals & (Percent of Yearly Total for All Species)							Totals and Percent of Grand Total for Entire Period
	1961	1962	1963	1964	1965	1967	1969	
ilia	9 (1)	4	1	5 (1)	9 (2)	4	5 (1)	37 (1)
judith	1	–	–	–	1	9 (1)	24 (4)	35 (1)
subnata	9 (1)	19 (1)	2 (1)	2	1	1	–	34 (1)
parta	9 (1)	2	6 (2)	3 (1)	4 (1)	7 (1)	2	33 (1)
unijuga	7 (1)	5	3 (1)	6 (1)	4 (1)	8 (1)	–	33 (1)
similis	7 (1)	7	1	–	1	4	–	20
flebilis	10 (1)	2	1	–	1	4	1	19
coccinata	7 (1)	4	1	2	1	2	2	19
praeclara	1	–	1	1	4 (1)	6 (1)	4 (1)	17
relicta	6	–	1	1	5 (1)	2	1	16
blandula	–	6	3 (1)	1	2	2	–	14
crataegi	1	2	1	1	–	2	1	8
innubens	1	–	–	–	2	1	–	4
amatrix	–	1	1	–	–	–	–	2
briseis	–	–	–	–	–	2	–	2
piatrix	1	–	–	–	–	–	–	1
cerogama	–	–	–	–	–	1	–	1
vidua	–	–	–	1	–	–	–	1
No. Species	33	29	31	30	32	35	28	39*
No. Individuals	1275	1412	306	530	553	1151	579	5806

* During the period 1952–60, one additional species was noted in this area—*C. robinsonii*, 15 September 1956, one specimen.

TABLE 3. Foodplants of the *Catocala* spp. from two localities.

Foodplants	Amherst, Mass.		Washington, Conn.	
	No. Species	% Total Individuals	No. Species	% Total Individuals
Salicaceae[1] Willow (*Salix*); Poplar (*Populus*)	7	13.9	7	7.6
Myricaceae[2] Bayberry (*Myrica*); Sweet Fern (*Comptonia*)	1	5.2	2	6.7
Juglandaceae[3] Walnut (*Juglans*); Hickory (*Carya*)	9	9.3	14	62.0
Fagaceae[4] Oak (*Quercus*)	5	39.4	5	9.7
Rosaceae[5] Apple (*Pyrus*); Thorn (*Crataegus*); Cherry (*Prunus*)	5	24.0	5	10.0
Ericaceae[6] Blueberry (*Vaccinium*); Andromeda (*Andromeda*)	3	6.0	3	3.7
Others[7]	3	2.1	3	0.4

Catocala species included:

[1] *relicta, parta, briseis, unijuga, cara, concumbens, amatrix*
[2] *antinympha, badia*
[3] *piatrix, epione, habilis, serena, judith, flebilis, obscura, residua, retecta, dejecta, vidua, palaeogama, subnata, neogama*
[4] *ilia, coccinata, similis, micronympha, amica*
[5] *ultronia, crataegi, mira, blandula, grynea*
[6] *gracilis, sordida, andromedae*
[7] *innubens* (*Gleditsia*), *cerogama* (*Tilia*), *praeclara* (*Quercus* ?, *Crataegus* ?).

Area 1 is near or beyond the northern limit of some of these *Catocala* species, due perhaps to a sparse distribution of certain foodplants, or to climatic marginality for the insects themselves.

The presence and absence of a foodplant seems to explain the single remaining difference in species between Areas 1 and 2 (i.e. bayberry, *Myrica pensylvanica* Loisel, the foodplant of *C. badia*, is present only in Area 2).

It is also possible, of course, that some differences in records from the two areas are due to differences in collecting procedures, which reflect, in turn, behavioral differences among the *Catocala* species. For example, *C. ilia* has been taken much more often at bait than at lights (96% of 371 captures in Leverett, 1967–69), and this fact may well explain its apparently higher numbers in Area 1 (and the consequent higher percentage of feeders on the Fagaceae). In contrast, *C. antinympha* has been more prevalent at lights than at bait (88% of 74 captures in Leverett, 1967–69),

TABLE 4. Early occurrence of several common *Catocala* species in two localities.

Species	Extreme Early Date Month/Day		Median Early Date Month/Day	
	Amherst	Washington	Amherst	Washington
antinympha	7/11	7/11	7/22	7/17
retecta	8/2	7/30	8/11	8/10
concumbens	7/21	7/23	7/31	7/31
ultronia	7/11	7/13	7/20	7/20
grynea	7/14	7/12	7/22	7/21
amica	7/2	7/12	7/25	7/21

and this could account for its apparently higher frequency in Area 2. Differences of this sort, as well as differences in the time of flight of the various species during the night, are being carefully studied, and will form the basis of further papers in this series.

Changes in Abundance. The records presented here do not cover a sufficient number of years to allow extended analyses of changes in abundance. However, the variations and trends in annual numbers of certain species warrant brief comment.

Several species exhibited wide fluctuations in annual abundance (e.g. *C. ilia* and *C. ultronia* in Area 1, *C. palaeogama* and *C. habilis* in Area 2, and *C. antinympha* in both areas). Two species in Area 1, *C. amatrix* and *C. residua*, were never recorded until 1969, and then both were relatively common. These fluctuations indicate that detecting long-term trends in *Catocala* abundance may often require longer series of annual records than those considered here.

The records from Area 2, together with notes of S. A. Hessel extending back to 1952, do indicate that two species, *C. serena* and *C. judith*, have recently become remarkably more common in that area. Although neither of these species was collected in Area 2 prior to 1960, since then 104 *serena* and 35 *judith* have been collected. These results could be due to erratic long-term oscillations in the abundance of these species, or might represent their recent range extension from more southern regions into Area 2. If these two species are presently extending their ranges, then we might eventually expect to take specimens in Area 1, where neither has yet been taken.

In all of the records from both areas, only one species, *C. subnata*, seems to be showing any evidence of a recent decline in numbers. This species is known as one which exhibits long-term fluctuations in abundance (Forbes, 1954).

TABLE 5. Seasonal occurrence of *Catocala*.

Species[1] (N)	Percent Occurrence							
	July		August		September		October	
	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
blandula (18)	61	28	6	6				
coccinata (27)	30	30	33	7				
similis (41)	12	68	17	2				
micronympha (155)	25	47	22	5	1			
ilia (717)	1	47	35	12	4			
ultronia (555)	1	41	39	17	1	–		
mira (69)	3	41	42	14				
epione (216)	2	37	46	15				
andromedae (169)	2	37	39	21	1			
antinympha (433)	4	34	43	15	3	1		
grynea (309)	1	29	42	27	2			
praeclara (46)	2	24	59	15				
gracilis & *sordida* (166)	6	29	29	35	1			
unijuga (66)	8	36	18	12	15	6	5	
amica (416)	1	25	35	27	10	1		
palaeogama (906)		34	25	20	13	8	–	
dejecta (40)		35	43	20	2			
badia (57)		37	49	11	3			
relicta (67)		36	40	19	3	1		
subnata (34)		26	32	24	18			
judith (135)		6	80	14				

[1] Species with less than 10 records not included.

TABLE 5. *Continued.*

Species[1] (N)	Percent Occurrence							
	July		August		September		October	
	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31
serena (103)		10	36	29	24	1		
residua (898)		5	37	30	19	8	1	
concumbens (385)		2	30	36	21	9	2	
retecta (401)		1	16	42	24	13	3	
cerogama (14)		7	7	71	14			
parta (34)		3		35	21	32	9	
obscura (130)		1	8	32	39	17	3	1
cara (126)			18	36	29	9	9	
flebilis (19)			11	58	11	21		
neogama (339)			10	34	32	19	5	
amatrix (38)			26	18	55			
habilis (661)			–	15	36	41	7	1

[1] Species with less than 10 records not included.

The wide annual variation in total *Catocala* individuals taken at any one locality seems largely due to dramatic fluctuations in the abundance of a very few common species (e.g. *C. ilia* and *C. ultronia* in Area 1; *C. palaeogama*, *C. residua*, and *C. habilis* in Area 2). Weather is another factor which undoubtedly influences records of annual abundance. It is well known among collectors that *Catocala* are more frequently taken on warm, humid nights; and thus the number of such nights during a summer will affect the total number of *Catocala* recorded. Data on temperature and humidity with respect to *Catocala* abundance will be obtained in our areas in subsequent years.

Seasonal Occurrence. The seasonal appearance of adult *Catocala* in Areas 1 and 2 seemed virtually identical. For example, of the 30 species common to both areas, 17 had earliest records of capture from Washington, and 12 had such records from Amherst (in one species the earliest re-

corded date was the same in both areas). Data on the early occurrence of the six species for which there are 50 or more records from each area are summarized in Table 4. (Late occurrences of the species could not be as meaningfully compared across areas because late season collecting was much less complete in Area 1 than in Area 2.)

A summary of the seasonal occurrence of the *Catocala* species is presented in Table 5. These data were obtained by summing across years and areas, a procedure which tends to extend the apparent season of each species to some extent. Nonetheless, it is clear that seasonal isolation alone is insufficient to separate most of the *Catocala* species from one another (all of the species, for example, may occur during the latter half of August). Some species may occur over the entire summer (e.g. *C. unijuga*, with extreme dates of 8 July and 9 October), and these certainly must be isolated from other species by factors other than seasonal occurrence. However, it seems equally clear that seasonal offset may coact with other factors in effectively isolating certain closely related pairs of species (e.g. *blandula* and *mira*, *serena* and *habilis*, *dejecta* and *retecta*, *subnata* and *neogama*).

Summary

Daily records of adult *Catocala* have been kept over several years at two localities in southern New England. For the period 1961–1969, nearly 8,000 individuals of 39 species were recorded. These data have been summarized here in an attempt to establish the abundance, and fluctuations in abundance, as well as the seasonal limits, of the species. In addition, suggestions relating to the differences in species composition at the two localities have been advanced.

Acknowledgments

This report was written while the first author was a visiting fellow in the laboratory of Dr. Charles L. Remington at Yale University. The stimulation of discussions with Dr. Remington, and his suggestions regarding this manuscript, are gratefully acknowledged.

Some of the *Catocala* records from the Amherst area were contributed by Dr. Ronald R. Keiper (1967–68) and Charles G. Kellogg (1969), and their cooperation and assistance is greatly appreciated.

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COMMUNAL ROOSTING IN *COLIAS* AND *PHOEBIS* (PIERIDAE)

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Two instances of communal roosting in coliadine pierids have recently come to my attention. They have to do with different genera, of considerably different body size, and occurring in different major environments, but there are several striking similarities and I believe a common explanation may satisfy both.

Colias eurytheme Boisduval

In an open meadow near Pittsburgh, Pennsylvania, at about 5:30 PM, EST, on 18 September 1969, I saw *Colias eurytheme* in fairly large numbers preparing for the night. A few of them were still active, but most had already sought roosts. The sun was within 15–20° of the true horizon, but was destined to disappear a little prematurely behind a low, tree-covered hill, and the field was already partly shaded.

A few *eurytheme* were down in the dense grass, probably within 6–8 inches of the ground, each some distance from any other. Some, similarly isolated, were low (less than a foot above the ground) in dense crown vetch on a steep, still sunlit, west-facing slope that forms the eastern edge of the field. Still others, also alone, were hanging from leaves of isolated emergent forbs, mostly goldenrod, usually within 1–2 feet of the ground.

I saw, however, two conspicuous aggregations. Each consisted of 5 males, clinging to the leaves of a clump (2 or 3 stalks) of emergent forbs in the middle of the field, the sun still on them. In each clump the individuals of *eurytheme* were only an inch or so apart and within a foot or two of the ground.

All the individuals I could examine closely enough, both those seen singly and those in the two aggregations, were basking laterally (wings appressed, the sun irradiating one side), the only basking posture I have ever seen in *Colias*. The orientation to the sun was so consistent that the best way to search for them was to keep the sun at my back as I looked: the little patches of sunlit yellow were conspicuous, even though some turned out on closer inspection to be merely yellowed leaves.

Phoebis sennae eubule Linnaeus

At Horseshoe Beach, Dixie Co., Florida, on 24 November 1969, at about 3:55 PM, EST, I saw an assemblage of *Phoebis sennae eubule*. In an empty trailer park consisting of bare sandy ground there were a few scattered low trees, mostly Sabal Palm. The trunk of one of these palms was nearly covered with a dense growth of a vine part of which, about six feet above the ground, was in the form of a hollow pocket about two feet across, facing west. In this pocket were 11 *sennae* (9♂, 2♀). The sun was low and much of the area was already shaded by some nearby buildings, although the *sennae* were still sunlit. Elsewhere, within a hundred feet or so, several *sennae* were still actively flying along with many other butterflies. Within the pocket of the vine, however, they were almost all in repose, wings appressed and broadside to the sun in the same lateral basking posture seen in *Colias*. There was one exception. When I approached the group one of the females had her wings fully outspread and and her abdomen elevated at right angles to the rest of her body and to the plane of her wings. This is known to be a rejection posture, a response to an attending male indicating that she is not receptive to copulation. The rest of the group was quiet, however, and she soon abandoned the posture and folded her wings together like the others.

Some ten or fifteen minutes earlier I had looked briefly at the assemblage and had noted only four or five individuals in it. I therefore

suspect that the group was slowly being added to by new arrivals. (Possibly one of these was a male who on arriving had attempted to copulate with the female and had elicited the rejection posture I saw.)

The color of *sennae eubule* is distinctly greenish yellow. The resemblance of the color of these individuals to the yellow-green leaves of the vine was so extremely exact that it was difficult to distinguish one from the other, even at close range.

Discussion

Nearly all the roosting *Colias* I saw, whether they were single or in the aggregations, were situated more or less close to yellowed or to yellowing leaves, whose color closely matched their own. An association of *Colias* with yellow flowers or leaves has long been known (Scudder 1889, p. 1123; Clark 1932, p. 159).

Several times I have noticed a similar association in *Phoebis*. In a locality in eastern Mexico I once saw them at rest in a low shrub with many yellow leaves. The size and color of these leaves so closely resembled the *Phoebis* that at a short distance it was impossible to tell which was which. At Chokoloskee, Collier Co., Florida, on 20 November 1969, I watched a *Phoebis agarithe maxima* Neumoegen in late morning, basking laterally for several minutes on a yellowed leaf of papaya along a path in a patch of low forest. This leaf was many times the size of the *agarithe*, but its orange yellow color was so close a match that the butterfly was almost invisible against it. This latter observation is particularly suggestive when taken in conjunction with the *sennae* already described. These two species are of about the same size but they are conspicuously differently colored: greenish-yellow in *sennae*, orange-yellow in *agarithe*. In each instance the background color closely resembled that of the particular species. See also Longstaff (1909, pp. 640–643).

Communal roosting is not well-known in either *Colias* or *Phoebis*. I think that in both genera it is an occasional occurrence only. This assumption is supported in *Colias* by the fact that at the same time that I saw the aggregations there were many other individuals preparing to roost alone. The above observations suggest the possibility that among the various factors that enter into the choice of a roosting site, the presence nearby of an appropriate shade of yellow is important. This may lead to single roosting individuals, but on the other hand, if the individual itself improves the color match or adds to the conspicuousness of the yellow at the site, then it may attract still others and result in an aggregation. In this sense, then, communal roosting may be simply a by-product of their xanthotropism.

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TWO NEW MEXICAN HESPERIIDAE

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Among the Hesperiidae collected by the Carnegie Museum-Catholic University of America expedition to eastern Mexico in January, 1966, were two short series of apparently new hesperiine skippers. When the Allyn Mexican expedition was undertaken in January and February, 1969, an opportunity was provided to obtain more specimens and to observe more closely the habits of these hesperiids. The combined series from the two trips comprise the type-series for the two new species below.

Although perhaps not so many specimens nor species can be taken in Mexico during the temperate zone winter as might be collected during the summer months, many worthwhile species apparently are found only during January and February, or at least are most abundant during this time. These two new skippers are evidently among such "winter" butterflies.

Vinius freemani Miller, **new species**

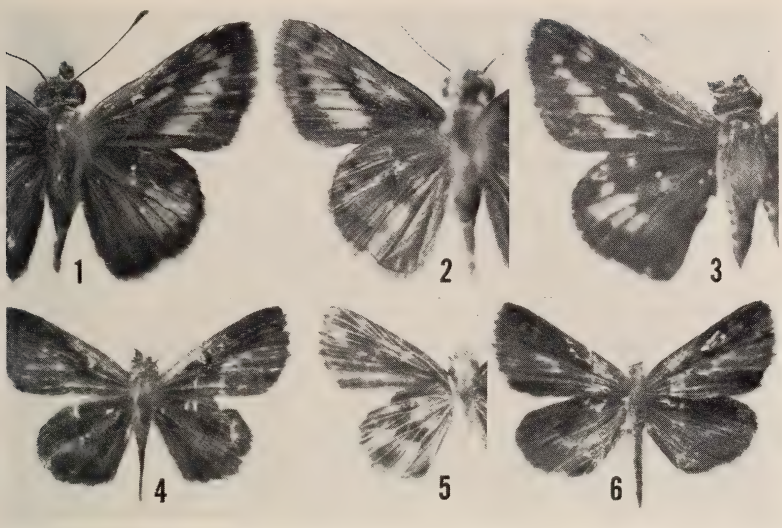
Figs. 1, 2 (♂), 3 (♀), 7 (♂ genitalia)

Male: Head, thorax and abdomen blackish-brown, clothed above with greenish-ochre hairs; below with dense tan hairs. Antennae brown above, ringed with brown and bright fulvous below; nudum dull brown. Palpi brownish-fulvous above, grayish-tan below. Legs densely clothed with brownish-fulvous hairs.

Upper surface of forewing reddish-fulvous with veins fuscous and with the following fuscous markings: apex and outer margin broadly dark; this border narrowing in space M_1–M_3, then broadening to anal angle; the border enclosing three light subapical spots in spaces R_3–R_4, R_4–R_5 and R_5–M_1. A dark streak bisecting discal cell throughout its length. A patch just distad of the cell in M_1–M_2 connecting the outer marginal band with the black androconial mass; latter passing along bases of spaces M_3–Cu_1 and Cu_1–Cu_2, then diagonally through space Cu_2–2A to 2A.

Hind wing fuscous above, densely overlaid with basal brownish hairs extending along the anal veins; a diffuse reddish-fulvous cell-spot; a short extradiscal band of same color composed of a small spot in space R_5–M_1, a long one in M_1–M_3 and somewhat shorter ones in M_3–Cu_1 and Cu_1–Cu_2. Fringes fulvous, darker from Cu_1 to apex of forewing, and plain or only slightly checkered.

Under surface of forewing broadly black basally and along anal cell to inner angle, the black continuing outwardly as a tapering submarginal band, broad in space Cu_2–2A and reduced to outer spots in M_1–M_3 and M_2–M_3 cells. Remainder of wing dull fulvous with the fuscous markings of upper surface lightly indicated by darker fulvous.



Figs. 1–6. New Hesperiidae from Mexico. 1, *Vinius freemani* Miller, holotype ♂, upper surface. 2, Same, under surface. 3, *Vinius freemani* Miller, paratype ♀, VERACRUZ: 2 mi. SE Coatzacoalcos, upper surface. 4, *Virga clenchi* Miller, holotype ♂, upper surface. 5, Same, under surface. 6, *Virga clenchi* Miller, paratype ♀, TABASCO: 2–3 mi. E LaVenta, upper surface. The figures are approximately twice life-size.

Under side hind wing fulvous, shaded with fuscous in space 2A–3A, and with an irregular fuscous spotband across discal cell from Sc–Rs to vein 2A (the spot in Sc–Rs distad of the others), and a V-shaped band of small fuscous spots in the same spaces, the one in M_2–M_3 nearest outer margin. Fringes fulvous, slightly darker toward apex of forewing, and slightly checkered with fuscous.

Forewing length of holotype, 12.0 mm., of the seven male paratypes, 11.5 to 12.5 mm., averaging 11.9 mm.

Male genitalia (Fig. 7) quite distinct from those of other *Vinius* species (see Hayward, 1950, pl. 10, fig. 13, and Evans, 1955, pl. 58), with simpler valvae and tip of penis with a long saw-like ventral projection.

Female: Body and appendages as in male, except that dorsal hairs darker, and ventral ones somewhat duller tan.

Upper side of forewing fuscous with dull fulvous markings as follows: two small spots near end of discal cell, the lower one somewhat the larger; three subapical spots as in male; an extradiscal band of spots beginning as a small dot in space M_1–M_2 marginad of subapical spots and proceeding posteriad and somewhat basad to a V-shaped spot in Cu_2–2A. Hind wing likewise fuscous above with a poorly defined dull fulvous cell-spot and a row of extradiscal fulvous spots as in male, but composed of smaller spots. Fringes light brown at anal angle of hind wing, shading to dark brown at forewing apex. Under surface like that of male, but darker and duller.

Ten female paratypes with forewing lengths of 11.5 to 13.5 mm., averaging 12.6 mm.

Described from eighteen specimens, eight males and ten females, from two localities near Coatzacoalcos, Veracruz, Mexico.

HOLOTYPE ♂: MEXICO: VERACRUZ: 2 mi. SE Coatzacoalcos, Sta. 24, grassy scrub/marsh/palmetto savanna association; 18-i-1966; H. K. Clench and L. D. Miller

(L. D. Miller specimen no. 1966–738); CM-CUA expedition.

PARATYPES: 6♂ 7♀, same locality and date as holotype. 1♂ 3♀, MEXICO: VERACRUZ: 1–2 mi. W Nanchital, sea level, savanna; 2-ii-1969, Sta. 19 (1♂ 2♀), 3-ii-1969, Sta. 21 (1♀); L. D. and J. Y. Miller; Allyn Mexican expedition.

Holotype and 4♂ and 6♀ paratypes in Carnegie Museum, 2♂ and 2♀ paratypes in Allyn collection, 1♂ and 1♀ paratypes in collection of H. A. Freeman and 1♀ paratype in collection of the Direccion General de la Faune Silvestre, Mexico, D. F.

I take great pleasure in naming this distinctive skipper for my good friend H. A. Freeman of Garland, Texas, in recognition of his magnificent work on the Hesperiidae of Mexico.

V. freemani will key to *letis* (Plötz) in Evans (1955, pp. 71–72). The under side of the hind wing of female *freemani*, however, is not noticeably greenish as in *letis*. Since *letis* is known only from southeastern Brazil, Paraguay and Argentina its conspecificity with the Mexican insect would be suspect, but the differences between the genitalia of *freemani* and *letis* are great, much greater than one could expect from the superficial similarities. *V. sagitta* (Mabille) from the Chiriqui, Panama, is clear yellow below, though marked rather like *freemani*, and the genitalia are different, whereas *V. t. tryhana* Kaye, which is known from Mexico, is very different superficially and genitalically.

I suspect that *freemani* has been overlooked by collectors since it looks and behaves rather like a small reddish version of the abundant *Hylephila phyleus phyleus* (Drury). Both species show a distinct preference for various white flowers in the Coatzacoalcos area and may be seen in swarms on suitable blossoms, occasionally a hundred or more *phyleus* and one or two *freemani* on a single bush. My wife and I collected more or less extensively in a number of other areas around Coatzacoalcos without finding *freemani*, and I believe this skipper is restricted to swampy savanna situations.

Virga clenchi Miller, **new species**

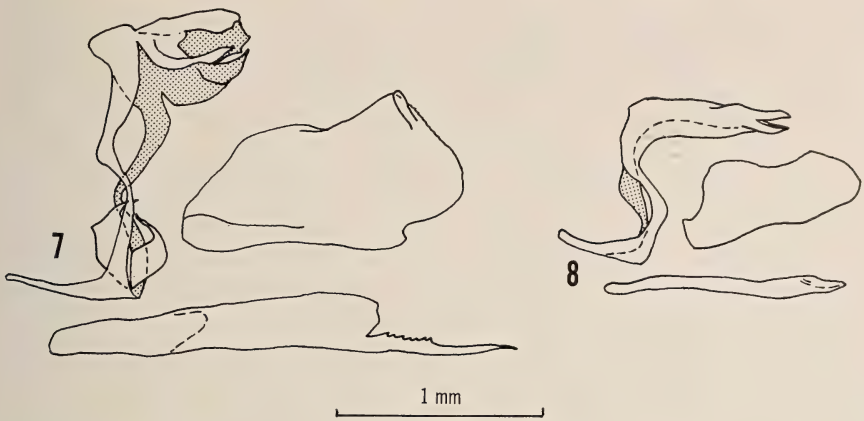
Figs. 4, 5 (♂), 6 (♀), 8 (♂ genitalia)

Male: Head, thorax and abdomen blackish-brown clothed above with dark-brown hairs, below with tan hairs. Antennal shaft brown above, yellow and brown ringed below; club brown above and yellow below; nudum dull brown. Palpi brown above, clothed with tan hairs below. Legs clothed with tan hairs.

Upper surface of forewing fuscous with a bronze cast and with fairly prominent bronze-fulvous extradiscal spots near bases of cells M_3–Cu_1 and Cu_1–Cu_2, a bronze-fulvous streak in space Cu_2–2A and some fulvous costal shading. In some specimens two or three light subapical spots vaguely indicated.

Hind wing above fuscous with a bronze sheen and an ill-defined band of extradiscal streaks from cell M_1–M_2 to cell Cu_2–2A. Fringes gray-brown with fuscous checkering on forewing.

Under surface of forewing fuscous with markings in M_3–Cu_1 and Cu_1–Cu_2 repeated in grayish, veins from Sc to Cu_1 yellowish distally and small gray subapical spots in spaces R_4–M_1 and M_2–M_3.



Figs. 7–8. ♂ genitalia of new Mexican Hesperiidae. 7, *Vinius freemani* Miller, genitalia of paratype ♂, VERACRUZ: 2 mi. SE Coatzacoalcos (LDM slide M-1577). 8, *Virga clenchi* Miller, genitalia of paratype ♂, VERACRUZ: 2 mi. SE Coatzacoalcos (LDM slide M-1581).

Hind wing below fuscous with basal grayish-tan area and an extradiscal band of same color from costa to Cu_2–2A; veins yellowish-gray. Fringes grayish-tan, those of forewing checkered with fuscous.

Forewing length of holotype, 9.0 mm., of the ten male paratypes, 8.5 to 9.5 mm., averaging 9.0 mm.

Male genitalia (Fig. 8) quite different from those of other two species known from Mexico and Central America, *virginius* (Möschler) and *xantho* (Schaus), figured by Evans (1955, pl. 59) and Godman and Salvin (1879–1901, pl. 103). *V. clenchi* especially characterized by simple valvae and long gnathos.

Female: Body and appendages as in male.

Upper surface of forewing fuscous with no bronze sheen and with bronze-fulvous spots in four of five specimens in spaces M_3–Cu_1 and Cu_1–Cu_2 and two subapical bronze spots in two of five specimens.

Hind wing above fuscous with poorly defined extradiscal bronze band as in male. Fringes as in male, but checkering more pronounced.

Under surface as in male.

Five female paratypes with forewing lengths of 9.0 to 10.0 mm., averaging 9.6 mm.

Described from sixteen specimens, eleven males and five females, from various localities in coastal southern Veracruz and northernmost Tabasco, Mexico.

HOLOTYPE ♂: MEXICO: VERACRUZ: 2 mi. SE Coatzacoalcos, Sta. 24, grassy scrub/marsh/palmetto savanna association; 18-i-1966; H. K. Clench and L. D. Miller (L. D. Miller specimen no. 1966–717); CM-CUA expedition.

PARATYPES: MEXICO: VERACRUZ: 2♂, 13 mi. NW Alvarado, 10 m.: Sta. 23 (CM-CUA); 16-i-1966; H. K. Clench and L. D. Miller (1♂); Sta. 12 (Allyn Mexican); 29-i-1969; L. D. and J. Y. Miller (1♂). 1♀, 16 mi. E Acayucan, Sta. 25 (CM-CUA); 18-i-1966; H. K. Clench and L. D. Miller. 2♂ 3♀, same locality and date as holotype. 1♂, 1–2 mi. W Nanchital, sea level savanna, Sta. 17 (Allyn Mexican); 1-ii-1969; L. D. and J. Y. Miller. 1♂, 5 mi. SE Coatzacoalcos, 10 m., dense scrubby swampland, Sta. 20 (Allyn Mexican); 3-ii-1969; L. D. and J. Y. Miller.

TABASCO: 4♂ 1♀, 2–3 mi. E LaVenta, 10 m., swamp forest, Sta. 15 (Allyn Mexican); 31-i-1969; L. D. and J. Y. Miller.

Holotype and 3♂ and 3♀ paratypes in Carnegie Museum, 5♂ and 1♀ paratypes in Allyn collection, 1♂ and 1♀ paratypes in collection of H. A. Freeman and 1♂ paratype in collection of the Direccion General de la Faune Silvestre, Mexico, D. F.

I am happy to name this little skipper for my friend and colleague Harry K. Clench of Carnegie Museum, Pittsburgh, Pennsylvania, who helped collect those specimens of the type-series collected by the Carnegie Museum—Catholic University of America expedition in 1966.

V. clenchi may have masqueraded in collections as *virginius* from which it may be distinguished by its smaller size, less prominent markings and the genitalic differences (for comparison see particularly the figure of the genitalia of *virginius*, as *cometho* Godman, in Godman and Salvin, 1879–1901, pl. 103). The present species is found in small numbers in a rather broad area along the southern coast of the Gulf of Mexico, usually in moist or swampy habitats, but its occurrence in a disturbed situation east of Acayucan demonstrates that *clenchi* is an adaptable insect. This Acayucan locality is not, however, far from the great marsh west of Coatzacoalcos, so the specimen might have strayed from a more suitable habitat. These butterflies are avid flower visitors, preferring white blooms, as do most skippers.

Finally, I would like to thank H. A. Freeman for checking these two skippers against his great Mexican hesperiid collection.

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VARIATIONS IN THE MARKINGS OF *PIERIS RAPAE* (PIERIDAE) INDUCED DURING THE PUPAL STAGE

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Introduction

The present work represents the conclusion of a study which has involved observations on the effects of feeding larvae certain chemicals (Kolyer, 1966) and on the effects of environmental factors (Kolyer, 1969) on the wing markings of the European cabbage butterfly *Pieris rapae* (Linnaeus). Specific objects were to note variations in markings as a result of (1) reduced-temperature storage of pupae of various ages, as an extension of previous work (Kolyer, 1969), (2) brief, barely sublethal heating of pupae, and (3) exposure of pupae to short-wave ultraviolet (UV) radiation. Incidental observations, e.g. on larval disease and the yellow form of *P. rapae*, also are included.

Experimental Procedures

Rearing. Final instar larvae were reared on an artificial diet at 79 ± 2°F and 45 ± 5% relative humidity under continuous cool white fluorescent light. Larval development was completed on cabbage leaves from refrigerated heads (see Kolyer, 1966); rearing room conditions were: 70–81°F, approx. 20–33% rel. hum., diffuse sunlight (March 6–April 17, 1969, Convent, New Jersey).

Refrigeration of pupae. As in previous work (Kolyer, 1969), pupae were packed carefully along with facial tissues in fiber mailing cans, which were covered with polyethylene bags to exclude moisture and stored in a refrigerator at 32–36°F for 154–156 days (approx. 5 months).

Heat treatment of pupae. Two test tubes, one inside the other, were immersed in hot water in a Dewar (vacuum-jacketed) vessel and allowed to equilibrate so that the temperature of the air within the inner tube approximated the temperature of the bath. Then pupae were added to the inner tube and allowed to remain for the specified time periods.

UV irradiation of pupae. Pupae were exposed, righthand wing case up, at a distance of 2 inches from an 8-watt glow discharge (mercury) lamp bulb giving light principally at 254 millimicrons. The intensity is given as 17 microwatts/cm.^{2} at 1 meter, which is "sufficient for effective air, surface, and liquid disinfection" (Anonymous, 1965). Temperature rise of a mercury thermometer bulb 2 inches from the lamp was considered negligible (0.5° C after 40 min. exposure).

Results and Discussion

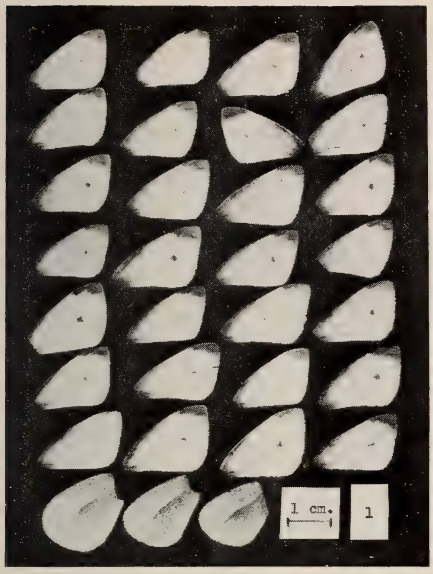
Variability of markings. The great variation in markings among individuals of *P. rapae* was mentioned in the earlier work. Wing length of this species varies from year to year (Petersen, 1947), and such variation also may be true of the proportion of "immaculata" (spotless form) males in the spring brood. Of 21 males taken at Flemington, New Jersey, on May 1, 1965, 11 were "immaculata" by the arbitrary criterion of less than 10 black scales in the forewing spot (Kolyer, 1966). In contrast, only 4 of 28 males taken on April 21–27, 1969, at Morristown, New Jersey (29 miles northeast of Flemington) were "immaculata" (No. 1, Plate I). Refrigeration of nondiapause pupae at 34–39°F for 5 months gave 5 "immaculata" of 21 males (Kolyer, 1969), thus surpassing natural conditions in producing this form in at least one instance.

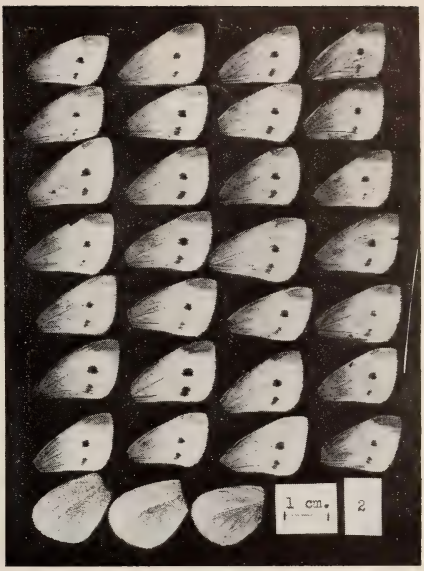
Controls—deformed head, yellow form. The control pupae were allowed to remain under rearing room conditions (cited above), and all adults eclosed in 9–12 days. Adult forewings are shown in No. 3, Plate I, and Nos. 5 and 6, Plate II.

The first control group (No. 3, Plate I) included an otherwise normal female with undeveloped head (no proboscis, palpi, or antennae), shown in No. 4, Plate I. A similar result was noted with a male adult fed the dye *safranin bluish* as a larva (Kolyer, 1965).

During completion of rearing of the second control group (Nos. 5 and 6, Plate II), a yellow-green larva, markedly different in shade from the other (grass-green) larvae, was isolated and reared to pupation. In 9 days a yellow-form male eclosed (the complete specimen in No. 5, Plate II). Since this was the only yellow form among 149 adults which eventually eclosed from the batch of larvae in question, the probability of having picked the yellow-form larva by chance alone was only 1.3%. A recessive yellow form of the larva of *Pieris napi* (L.) has been described (Gladman, 1962), but adults in this case are normal in appearance. Incidentally, the complete specimen (male) in No. 3, Plate I, also is a yellow form.

Larval disease. A minority of larvae evidenced black spots (appearing under magnification as black-rimmed pits) on the integument. Two of these larvae were sent to Mr. G. M. Thomas of the University of California (see Acknowledgments) for a disease diagnosis. The larvae were found to suffer a bacteriosis caused by a strain of the rather common insect pathogen *Serratia marcescens* (Bizio). This strain was nonchromogenic in culture, and association of the disease with the black spots is speculative. Such dark spots on larvae usually are symptomatic of microsporidian





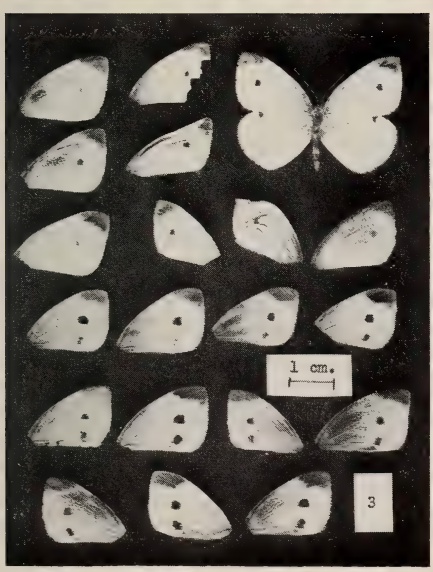




PLATE I

Specimens of *Pieris rapae* (L.). 1, 2, Forewings (and underside of hind wings in bottom rows) of series taken at Morristown, New Jersey, on April 21–27, 1969: 1, ♂♂; 2, ♀♀; 3, control group (pupae developed at 70–81° F) for Nos. 7–9, Plate II; 4, ♀ from preceding control group with undeveloped head, photographed through 16× microscope.

infections, but no protozoans were found, nor was there evidence of virus, fungi, or nematodes.

Some of the spotted larvae died, or yielded deformed pupae which died, but others gave normal pupae and adults. One adult was sent to Mr. Thomas. Thorough examination of the tissues and blood revealed no microbial etiology; a complete analysis showed no bacteria, protozoans, virus, fungi, or nematodes.

Refrigeration of pupae. In the previous work (Kolyer, 1969), nondiapause pupae were refrigerated (34–39°F) at an age of 12–24 hours from pupation (final molt); after 5 months these pupae were allowed to develop at room temperature and yielded adults with significantly reduced (spring brood) markings.

In the present study, pupae of various ages were refrigerated (32–36°F) for 5 months with the objective of gaining information on the time of determination of the markings. In the meal moth *Ephestia kühniella* (Zeller), and in Lepidoptera in general, the wing pattern is completely determined early in the pupal stage (Magnussen, 1933, and Pohley, 1959). In *P. rapae* pupae the spots have been determined at least by the time of visible deposition of white pigments (pupal age about 135 hours), as shown by the lack of white pigment in the scales within the spot at this time.

Refrigeration results are given in Table 1; two control groups are involved because the larvae had been received from the Department of Agriculture in two separate batches about one month apart. From the 24–34 hour old pupae, eight of twelve normally-expanded males were "immaculata." Refrigerated females tended to lack the apical marking and to have weak spots; in one case both spots and apical marking were almost completely absent (middle wing in 4th row, No. 10, Plate III). Melanization of the underside of the hind wings, as in the spring brood, also occurred (see No. 10, Plate III).

The conclusion is that these nondiapause pupae had to be refrigerated at an age of less than 48 hours to allow suspension of development and eventual eclosion. Also, the lack of reduction of markings on the pupal wings of the 48–56 hour old group (No. 9, Plate II) suggests that the markings have been determined by 48 hours. Concurrent studies indicate that the scales develop at some point between 27 and 87 hours, and it may be that the fate of a scale to be white or black must be decided *before* the scale grows out from the original stem cell. (As described by Lipp (1957), the wing epithelium of the freshly-molted *P. brassicae* pupa is composed exclusively of stem cells which later give the scale and socket arrangement.) Unexpectedly, one male in the 133–143 hour old group managed

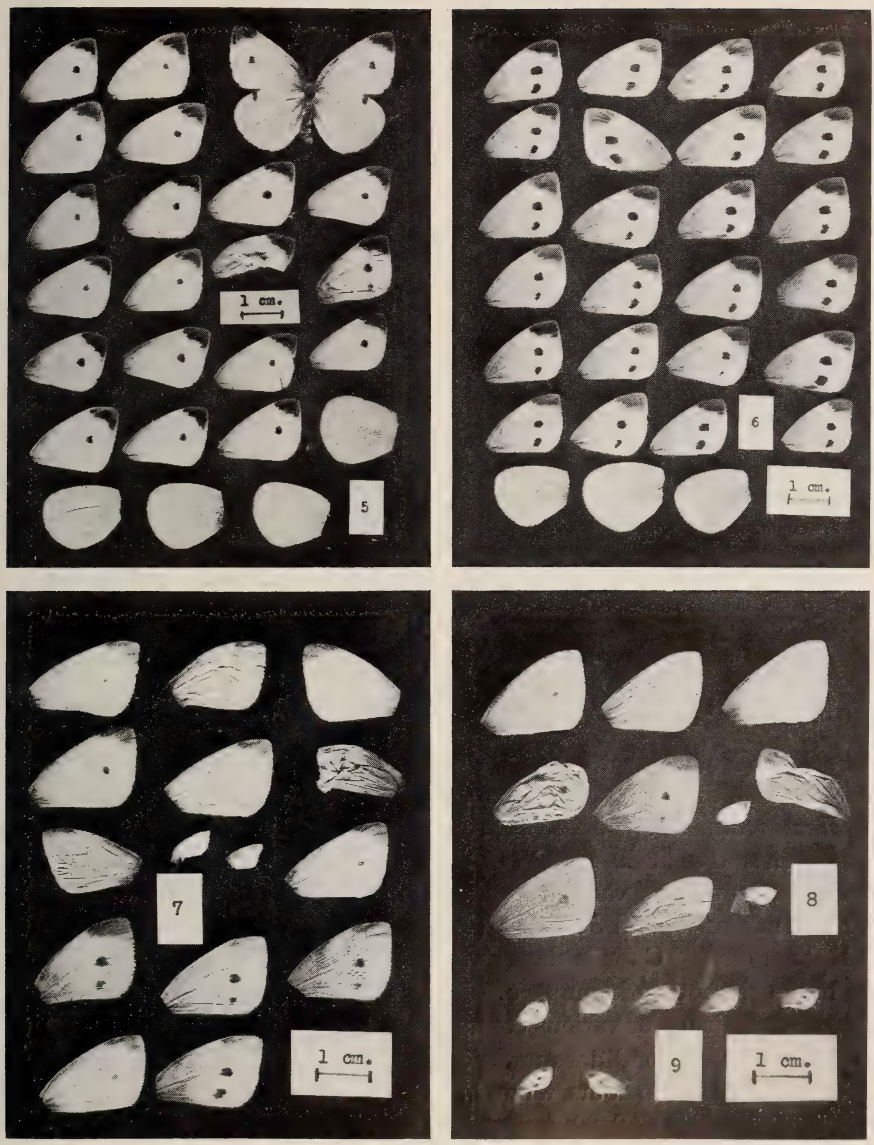


PLATE II

Specimens of *Pieris rapae* (L.). 5, 6, Forewings (and underside of hind wings at bottom) of control group (pupae developed at 70–81° F) for Nos. 10–15, Plate III: 5, ♂♂; 6, ♀♀; 7–9, forewings of adults from pupae refrigerated at 32–36° F for 5 months, pupae refrigerated at specified time from pupation: 7, 10–18 hours; 8, 24–34 hours; 9, 48–56 hours.

TABLE 1. Data on pupae refrigerated for five months.

Pupal Age (hours) When Refrigerated	Control Group No. in Plates	No. Eclosed[1]		Crumpled	No. Died[3]	Notes
		Fully Expanded				
		Males[2]	Females			
10–18	3	6 (1)	4	3	17	Many dead pupae showed light markings.
24–34	3	3 (2)	2	4	21	Ditto.
24–34	5 & 6	9 (6)	15	7	19	Ditto.
48–56	3	0	0	0	29	Some pupal wings showed markings—essentially like summer brood.
78–88	3	0	0	0	29	—
80–86	5 & 6	0	0	0	57	Most had black wing cases.
103–109	5 & 6	0	0	0	51	Some with black wing cases; 5 showed markings —like summer brood.
120–130	3	0	0	0	31	—
133–143[4]	5 & 6	1 (0)	0	0	48	One with black wing cases; 8 showed markings— like summer brood.
Controls	3, 5 & 6	total of 72		2	1	—

[1] Eclosion was completed within 11 days after removal to rearing room conditions 71–83° F, 50–57% rel. hum.).

[2] The number of "immaculata" form is given in parentheses.

[3] Many died after the pupal wing markings had developed. In the case of several pupae (total of 11 for entire column) the adult split the pupal case but failed to emerge.

[4] The wing cases were white (pigment deposited).

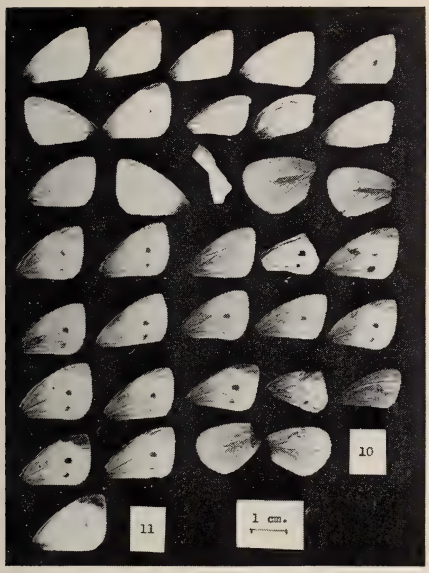
to eclose (No. 11, Plate III); the markings seemed not significantly less intense than those of the control males.

Heat treatment of pupae. A fatal high temperature for butterfly pupae has been said to be 39–42° C (Uvarov, 1931), but Kühn (1936) subjected meal moth pupae of various ages to 45° C for 45 minutes to observe effect on the markings, and Schrader (1929) exposed pupae of *Vanessa carye* (Hübner) to 48° C for "a short time" to cause aberrations.

In the present work, pupae of various ages (from 10 to 128 hours) were exposed to air under various conditions within the limits of 36–48° C and 10–30 minutes. Conditions under which all pupae died were (number of pupae, pupal age in hours, temp. in ° C, time in min.): 6, 10–18, 45.3–48.3, 20; 2, 21–27, 43.8–47.0, 20; 4, 23–39, 43.3–46.6, 30. Among conditions which allowed all pupae to live and yield adults were: 4, 13–18, 36.3–39.1, 30; 7, 19–25, 38.9–45.0, 10; 4, 22–28, 41.6–46.4, 20; 2, 24–32, 41.8–45.3, 25. These

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Specimens of *Pieris rapae* (L.). 10, Forewings (and undersides of hind wings for 2 ♂ ♂ and 2 ♀ ♀) of ♂ ♂ (first 3 rows) and ♀ ♀ from pupae refrigerated (at 24–34 hours from pupation) at 32–36° F for 5 months; 11, forewing of ♂ from pupa



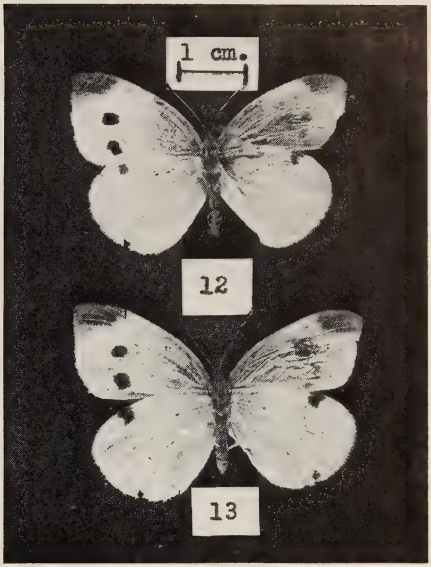






Plate III

similarly refrigerated at 133–143 hours from pupation; 12, 13, ♀ ♀ from pupae which had right wing cases exposed to UV light (see text); 12, 12 hours exposure; 13, 36 hours exposure; 14, 15, wings of adults from pupae exposed to air at 41.4–47.5° C for 20 min. (see text); 14, largely-scaleless forewing of ♀, photographed through a 16× microscope against a black background; 15, forewing of ♂ with side-lighting to illustrate "bumpy" surface, photographed through 16× microscope.

results suggest that surviving pupae had been exposed to very nearly lethal conditions. However, normal specimens with summer brood markings (like the controls) resulted in almost all instances.

Pronounced structural abnormalities occurred in only one case (conditions: 14, 74–84, 41.4–47.5, 20). Two pupae died, one adult split the pupal case but failed to eclose, 3 pulled partly out of the case, 7 had crumpled wings, and only one (male) expanded normally. One female had particularly wrinkled and distorted wings with a high degree of scalelessness, but the markings (spots) still were visible; No. 14, Plate III, shows the forewing in the region of the spot photographed against a black background. The normally-expanded male had "rough" wings on close examination, due to erection of isolated patches of scales. The other individuals had more or less crumpled wings, in some cases with an unusual "bumpy" appearance though well clothed with scales (as illustrated in No. 15, Plate III).

Dehydration has been suggested to explain changes in meal moth wing pattern caused by heating pupae at about 45° C for 45 minutes (Braun, 1939), but the weight loss for the *P. rapae* pupae heated at 41.4–47.5° C for 20 min. was only 0.3% (14 pupae weighed 2.185 grams before heating, 2.178 grams after heating).

Scale loss as a result of heating pupae has been noted for the meal moth (Kühn and Merkel, 1955). Also, the present results, especially for the female shown in No. 14, Plate III, are reminiscent of the effects, including wrinkling and scalelessness, reported for *Papilio* pupae subjected to beta rays (Kishi, Miwa, and Mori, 1942). In conclusion, heating *P. rapae* pupae failed to change the distribution of melanin but did, in one case, cause considerable structural deformity.

UV irradiation of pupae. Young pupae of the meal moth were irradiated with UV light from a mercury lamp by Köhler (1941) to give disturbances in scale arrangement and transformations in pattern.

Thirty-six *P. rapae* pupae, 50–60 hours old, were placed under the UV lamp as described under "Experimental Procedures" above. Twelve were removed from the light after 2 hours exposure, twelve more after 12 hours total exposure, and the rest after 36 hours total exposure. Results were (exposure time in hours, males expanded normally, females expanded normally, individuals with right wing crumpled, individuals with both wings crumpled): 2, 4, 2, 7, 1; 12, 3, 5, 6, 0; 36, 5, 2, 6, 1. (Of 45 controls, all eclosed, and only 2 had crumpled wings.) The adults eclosed 8–10 days from pupation (conditions: 70–81° F, 28–33% rel. hum.), with the exception of one female which eclosed about 25 days from pupation.

Three of the normally-expanded females had notably asymmetric

markings. Two (Nos. 12 and 13) are shown in Plate III. Examination of the wings under a 16× microscope showed that the scales on the upper surface of the forewing had a shriveled, narrowed appearance. Within the spot the scales were essentially white, the gray appearance of the spot being due to the presence of normally-pigmented black scales within the spot on the lower wing surface, beneath the transparent membrane. In these cases the effect of UV irradiation seemed to be to deform the scales and prevent those scales in the spot from undergoing black pigmentation (melanin formation), a process that begins approximately 25 hours before eclosion.

Summary

The European cabbage butterfly *Pieris rapae* (Linnaeus) has variable black markings which may be much reduced in the spring brood, even to the extent of disappearance of the forewing spot in the male ("immaculata" form). Attempts were made to influence these markings by various treatments of nondiapause pupae originating from larvae reared at 79°F under continuous light.

Refrigeration of 24–34 hour old pupae at 32–36° F for 5 months gave a high proportion (8 of 12) of males of the "immaculata" form and females with much reduced apical markings and weak spots (in one case virtually no markings at all). Reduction in markings also was achieved with 10–18 hour old pupae. However, pupae varying in age from 48 to 143 hours (white pigment appears at about 135 hours) failed to eclose with only one exception (a 133–143 hour old pupa, which yielded a male with unreduced markings), and the markings sometimes visible on the pupal wings were little reduced. This suggests that to affect markings refrigeration must precede outgrowth of the scales from the stem cells of the wing epithelium.

Heating of pupae under barely sublethal conditions failed to cause redistribution of melanin but produced structural deformities in one experiment (74–84 hour old pupae exposed to air at 41–48° C for 20 minutes); the wings were partly scaleless and wrinkled in several cases and were highly deformed and largely scaleless in one individual.

Exposure of 50–60 hour old pupae to UV light (largely 254 millimicrons) caused deformity of the scales in some individuals, with lack of black pigmentation of scales within the forewing spots on the upper, but not the under, surface of the exposed wing.

All these results seem consistent with final determination of the wing pattern early in the pupal stage, as reported for the meal moth *Ephestia kühniella* (Zeller) in intensive studies by Kühn and others.

Acknowledgments

The author gratefully acknowledges the contribution of larvae for this and other work by the Columbia, Missouri station of the United States Department of Agriculture, where Mr. Benjamin Puttler was Assistant Director and Mr. Richard K. Morrison was in charge of the insectary rearing program. The author also is indebted to Mr. Gerard M. Thomas of the Agricultural Experiment Station, College of Agricultural Sciences, University of California, Berkeley, for the disease diagnoses.

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THE BIOLOGY AND LABORATORY CULTURE OF *CHLOSYNE LACINIA* GEYER (NYMPHALIDAE)

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The nymphalid butterfly, *Chlosyne lacinia* Geyer, is the most widely distributed species of its genus, ranging from Argentina northward into Texas, New Mexico, Arizona, and the Imperial Valley and adjacent desert areas of California (Comstock, 1927; Ehrlich and Ehrlich, 1961). Occasionally it may penetrate as far north as Kansas and Nebraska (Klots, 1951).

The objective of this paper is to present an outline of the life history and laboratory rearing techniques established as a result of an investigation recently initiated on the ecological genetics of the various color morphs present in the Texas populations. Details concerning the inheritance and fitness in natural populations of certain color morphs will be published later.

Rearing

Larvae of *Chlosyne lacinia* were reared in the laboratory from egg masses collected in the field or laid in the laboratory by wild-caught females. Individual 4 and 6 quart polyethylene tubs with tight-sealing lids were used to hold the larvae of separate broods in early rearing procedures. Both ventilated and unventilated lids were tried. The larvae were supplied daily with fresh leaves of *Helianthus annuus* and the containers cleaned of frass.

No attempt was made to regulate humidity, but larvae in unventilated tubs in which the humidity was high (90% or more) developed more rapidly than those in the ventilated tubs. However, at high humidity the larvae were much more susceptible to disease; mortality was particularly high in the fourth and fifth instars. Most containers were kept at a constant 21° C under artificial light of 16 hour daylength. It was noted during the early attempts at rearing that larvae developed more rapidly at higher temperatures but were more subject to disease. Although the use of ventilated lids reduced mortality of larvae reared at high temperature, the *Helianthus* leaves dried out within a matter of hours, rendering them inedible to the larvae and thus lengthening developmental time.

The feeding and disease problem was satisfactorily solved by employing the Special Vanderzant-Adkisson Modified Wheat Germ Diet (Adkisson et al., 1960) as an artificial medium (available commercially from Nutritional

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Biochemical Company, Cleveland, Ohio 44128). The medium was supplemented with the antibiotics aureomycin and acromycin, as well as methyl parasept; these were added at the concentration of 0.001% by weight to help check disease. Finely ground dried *Helianthus* leaves (2.5 to 10% by weight) were normally included as a feeding stimulant. Although larvae have been raised on media lacking the *Helianthus* additives, they developed more rapidly and only acquired full coloration on the diet supplemented with leaves, particularly at the higher concentrations.

Larvae raised on the artificial medium were normally kept at 24°–26° C under a 16 hour daylength or under continuous lighting; the latter condition caused some larvae to enter diapause. At this temperature the medium, which was placed in strips on the bottom of unventilated polyethylene containers, required changing only once a week for the first three instars, and only slightly more often as the larvae increased in size.

Mortality of medium-raised larvae was low through the first four instars, but the fifth instar larvae were quite susceptible to infection. The overall incidence of infection, however, was much lower than in larvae reared on leaves alone. The medium apparently fulfilled most of the nutritional requirements of this butterfly since it supported three generations of insects in our laboratories. The effects of the diet on fecundity and viability were not established but are now under study.

Adults were collected by placing pupae in one-pint paper ice cream cartons, the solid tops of which were replaced with gauze. Upon emergence, the adults were maintained under an artificial 16 hour day and fed once or twice a day on a solution of one-third honey (or sugar) and water (1:3 by volume) soaked into pieces of sponge or commercially available pressed cotton (Coets, Quilted Squares; Personal Products Company, Milltown, New Jersey) placed on the gauze.

Mating was accomplished either in small wire cages under the partial shade of a tree or in large indoor mating cages artificially lighted with a bank of four Gro-Lux fluorescent lights. High frequencies of mating occurred when these cages contained several adults. In these same large cages small *Helianthus* plants were available for the females to oviposit upon, following mating.

Life History

Chlosyne lacinia in central Texas is multiple brooded; a generation occurs about every 35–45 days under field conditions. Adults fly from March to November with individuals apparently passing the winter as diapausing third instar larvae (there are five larval instars). Diapause appears to be a photoperiodic response because larvae frequently entered diapause in

the third instar when they were held in the laboratory under light conditions of short day length (i.e. 8–12 hours).

Larvae in central Texas appear to feed primarily on species of the tribe Heliantheae (Compositae). The primary larval foodplant from March through July is the sunflower, *Helianthus annuus* L. It may feed occasionally on *H. cucumerifolius* Torr. and Gray, *Ambrosia trifida* var. *texana* Scheele, *Verbesina virginica* L. and *Silphium* sp. (Kendall, 1959, and personal communication). We have also found a few broods on *Viguiera dentata* (Cav.) Spreng. and *Simsia calva* (Engelm. and Gray) Gray. As *H. annuus* dies out in August, females begin to oviposit on *Ximenesia encelioides* Cav. During this period larvae can be found feeding on both host plants.

Mating usually occurs in midmorning with copulation lasting about forty-five minutes. Up to 500 eggs may be deposited in one or two clusters by a female on the underside of a host plant leaf. Counts made of day-old larvae from 75 collected wild egg masses revealed an average of 139 (Se = ± 11) hatched eggs per mass, with a range of 22 to 480.

The initial pale greenish-yellow egg color changes to dark brown 24–48 hours before hatching. The pale yellow larvae of a single egg mass hatch simultaneously. After consuming the empty eggs, they begin feeding gregariously on a thin silken web in a tightly packed mass on the underside of the host plant leaf. When disturbed, first and second instar larvae frequently will begin a synchronous jerking movement of the body. The function of the web is not known, but it may possibly help to maintain colony unity and protect the larvae from some predators and parasites.

When a leaf has been consumed, one or two larvae will move off the leaf along the stem followed in single file by the rest of the brood. Each larva lays down a silken thread which is reinforced by the larvae following it. A distinct silken trail is thus constructed by the group. Upon arrival at a new leaf, the feeding aggregation is reformed (Bush, 1969).

Third to fifth instar larvae may enter a quiescent period during the month of August in Texas when the temperature is high and food plants are scarce. In the laboratory, unfed larvae in the later stages (primarily third and fourth instar) will contract and remain quiescent for up to two months or more and resume feeding and complete development when food is provided. Mr. Roy Kendall has informed us that he has been able to maintain unfed larvae of *C. lacinia* for over a year. Thus it appears that this species is well adapted to the xeric conditions of central Texas.

Usually by the fourth instar, the larvae within a brood begin dispersing singly or in small groups and may move to adjacent plants, becoming well scattered by the fifth instar. Dispersal appears to coincide with the ap-

TABLE 1. Life table of *Chlosyne lacinia* reared on sunflower leaves in the laboratory at 21° Centigrade.

	1st instar larvae per egg mass	Incubation period (days)	Instar 1 (days)	Instar 2 (days)	Instar 3 (days)	Instar 4 (days)	Instar 5 (days)	Pupa (days)	Total time egg–adult (days)
Mean	138.8	9.10	7.8	4.5	3.7	7.2	12.0	9.0	53.3
Range	22–480	6–15	7–8	4–5	3–5	5–9	4–22	7–11	—[2]
No. of broods	75	13	6	6	6	6	5	21[1]	

[1] Number of individuals.
[2] The range of the total developmental time could not be determined with accuracy because the egg masses used to calculate the incubation period and the broods used to obtain data on the length of the larval instars were not necessarily the same.

pearance of larval color patterns which usually begin to manifest themselves in the third instar and are quite well developed by the fifth. In one color phase, the ground color is black, in another the ground color is almost solid orange, and in a third the ground color is black with an orange dorsal stripe. More detailed descriptions of the immature stages of this butterfly may be found in Edwards (1893).

The function of dispersal is not clear, though perhaps it is primarily the result of food competition. It may also serve to reduce the incidence of disease, parasitism, and predation among individual larvae of the same brood. This interpretation is supported by the fact that fourth and fifth larval instars under crowded laboratory rearing conditions were much more susceptible to disease, which is apparently quiet contagious, than were the earlier stages under the same conditions. As will be discussed in more detail later, mature larvae were also more susceptible to parasitism than earlier stages and predation appeared to be greatest among third to fifth instar larvae.

Fifth instar *Chlosyne* larvae frequently wander a considerable distance from their feeding site prior to pupation, which may occur on sheltered sites on a wide variety of surfaces such as *Helianthus* stems, fence posts, or leaves. The base color of the pupal case changes after 24 hours from pinkish-white to ivory or yellow. It is often speckled with highly variable black markings, producing intergrades between pure white and almost black pupal cases. Male pupae are slightly smaller than females and within a given brood emerge approximately 24–36 hours before the females.

Laboratory breeding experience revealed that emerged females must usually mature for one or two days prior to mating, thus producing a 2 to 3 day lag between the sexual maturity of the male, which may mate the same day of emergence, and the female. A delay in the emergence and

TABLE 2. Life table of *Chlosyne lacinia* reared individually on standard laboratory diet with ground sunflower leaves at 22°–23° C.

	Incubation period	Instar 1	Instar 2	Instar 3	Instar 4	Instar 5	Pupa	Total time egg–adult
Mean (days)	10.76	7.56	4.87	6.54	8.97	9.21	7.32	53.67
S.E.	±.09	±.13	±.27	±.37	±.73	±.44	±.18	±1.12
Range	10–14	5–10	3–12	2–13	5–21	5–14	6–9	45–64
No. of individuals	98	85	70	57	34	29	28	28
died	—	15	16	11	1	0	1	43
diapause	—	0	0	2	23	4	0	29

mating of females would tend to reduce inbreeding by encouraging dispersal among individuals within a brood prior to mating. This is the opposite of maturation in *Euphydryas editha* and *Cercyonis* species, where females can and do mate immediately upon emergence but males must mature at least 24 hours before mating attempts are made (Emmel, 1969).

Two life tables for *Chlosyne lacinia* are presented in Tables 1 and 2. Table 1 was compiled from data collected from mass rearings of broods at 21° C on *H. annuus* leaves. When at least 50% of the larvae had molted the date was recorded. As all individuals in a brood usually develop synchronously, this instar molting time involved little intrabrood variance. Those that failed to molt were usually diseased or parasitized.

Table 2 represents the time required for individual larvae to reach the adult stage. These larvae were selected at random from different broods and reared in isolation on laboratory media at 22°–23° C and constant light. The results obtained from the two methods of rearing appear to be in fairly close agreement. It is apparent, however, that the life cycle takes considerably longer in the laboratory than under field conditions, though accurate life tables have not been compiled for wild broods. The principal reason for faster development in the field may be the higher diurnal temperatures (to 39° C) which increase larval feeding and hence growth rates.

Parasitism and Predation

Parasitism

It is clear the parasitism accounts for a considerable portion of the mortality occurring from the egg to the adult stage in natural populations. However, because of the sampling methods employed and the increased rate of parasitism with larval maturity, it was not possible to obtain an accurate overall estimate of the rate of parasitism and its effects on natural populations.

TABLE 3. Rates of parasitism by the braconids *Apanteles lunatus* and *A. rufocoxalis*. Larvae were collected at the instar indicated and held in the laboratory until the parasites emerged. Fourth and fifth instar broods were collected on plants isolated from other broods to insure that all individuals came from the same brood.

Stadium	No. of Broods	Broods Parasitized	No. of Larvae	Larvae Parasitized	% Broods Parasitized	% Larvae Parasitized	% Larvae Parasitized per Parasitized Brood
Instar I	6	2	518	3	33.3	0.6	1.2
Instar II	66	35	7846	359	53.0	4.6	8.2
Instar III	35	26	3490	365	74.3	16.2	25.0
Instar IV	10	6	1411	292	60.0	20.7	32.0
Instar V	5	4	222	108	80.0	48.6	52.2

The following parasites have been reared from the eggs, larvae, and pupae of *C. lacinia.*

Egg: *Trichogramma fasciatium* (Perkins) (Trichogrammatidae) is the only parasite thus far reared from the eggs of *C. lacinia.* Generally all the eggs in an infested egg mass were parasitized. Ten out of eighty-two egg masses (12.2%) were parasitized from collections made at three localities (Stockdale, Wilson Co.; Czestochowa and Kenedy, Karnes Co.) on June 18, 1968.

Larvae: One species of Braconidae, *Apanteles lunatus* (Packard) was found to parasitize all larval stages. A full grown *Apanteles* larva never emerged from a host before the host had reached the third instar. Upon emerging, the parasite spun a bright yellow cocoon on the leaf beside the moribund host. The frequency of larval parasitism was directly correlated with the stage of development as indicated in Table 3. Individuals in broods collected in the first instar and held in the laboratory were rarely parasitized (0.6%), while approximately 48.6% of all fifth instar larvae collected in the field were parasitized.

There was some indication that the three larval morphs were differentially parasitized. Orange larvae, for instance, were rarely parasitized, while black larvae appeared to be more heavily parasitized by *Apanteles* than the striped larvae. These situations of selective parasitism are now under study.

Pupae: Three parasite species were reared from a few *C. lacinia* pupae collected as larvae or pupae in the field. The most frequently encountered parasite was a small pteromalid, *Pteromalus archippi* Howards, which oviposits in fully formed *lacinia* pupae. Two other Hymenoptera, the ichneumonid *Cratichneumon vinnulus* (Cresson) and the chalcid *Spilochalcis phoenica* Burks, have also been reared from pupae of *lacinia.* Apparently *S. phoenica* oviposits only on the pupal stage of this host, while *C.*

vinnulus was reared from a pupa which was collected as a fifth instar larva. Two species of Tachinidae, *Eupharocera daripennis* (Marquart) and *Siphosturmia melitaeae* (Cog.), are common *lacinia* parasites, but apparently oviposit on fourth and fifth instar larvae. Of 177 larvae collected at random in the last two instars, 14.1% were parasitized by these flies.

Predation

Predators take a heavy toll of larvae and adults, but no field observations have yet been made on the predation of the egg and pupal states. One of the most frequently encountered predators was a metallic-blue pentatomid bug, *Stiretrus anchorago* (Fabricius). Most often attacking third and fourth instar larvae, these bugs would sometimes almost completely destroy a brood.

Members of the wasp genus *Polistes* (Vespidae) are also common predators of primarily fourth and fifth instar *C. lacinia* larvae. Two species, *P. annularis* (L.) and *P. exclamans* Viereck have been identified, but others undoubtedly prey on the larvae. Individuals of both species have been observed to return repeatedly to the same plant and systematically strip a sunflower of almost all larvae.

Birds and lizards, both common in the study areas, have never been observed to feed on any stage of this butterfly. Unidentified species of jumping spiders (Salticidae), on the other hand, have been observed capturing and feeding on adults and the butterfly has also been found in the webs of the orb spiders *Argiope aurantia* Lucas and *A. trifasciata* (Forskal) (Argiopidae).

Acknowledgments

We would like to express our appreciation for the identification of parasites to B. D. Burks (Chalcididae, Pteromalidae, and Ichneumonidae), R. C. Froeschner (Pentatomidae), P. M. Marsh (Braconidae), A. J. Menke (Vespidae) of the Systematic Entomology Laboratory, U.S.D.A.; D. M. Wood (Tachinidae) of the Canada Department of Agriculture; and H. J. Einhard (Tachinidae), College Station, Texas. We would also like to thank N. Price, J. Lee, P. Barton, and R. Neck for their assistance in rearing the larvae. Particular thanks are due Mr. B. W. Records who carried out the individual rearing test. Roy O. Kendall, San Antonio, Texas, gave generously of his time and advice on this research.

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Summary

1. The nymphalid butterfly, *Chlosyne lacinia* Geyer, ranges from South America to the southwestern United States and is polymorphic in the larval, pupal, and adult

stages. Features of this species' biology make it exceptionally suitable for studies in ecological genetics of natural populations.

2. Techniques for rearing *Chlosyne lacinia* in the laboratory are described. The most satisfactory method of rearing is on an artificial medium (the Special Vanderzant-Adkisson Modified Wheat Germ Diet, with antibiotics and powdered *Helianthus* sunflower leaf additives) under a 16 hour photoperiod at about 25° C. Adults are kept in one-pint ice cream cartons with netting tops, and are fed daily with a honey (or sugar) water solution. Mating will take place in cages under florescent lights as well as sunlight.

3. The primary natural food plant from March through July in Texas is the sunflower, *Helianthus annuus* L. When this species dies in August, female butterflies begin to oviposit on *Ximenesia encelioides* Cav. Several other representatives of the Heliantheae (Compositae) which serve as secondary hosts are discussed.

4. *Chlosyne lacinia* lays large clusters of eggs and the larvae are gregarious until the fourth instar when they disperse. A silken trail is laid down and followed by larvae moving from one leaf to another during the gregarious phase. Black, orange, and black-with-orange-stripe color morphs occur in the larvae (clearly recognizable at fourth and fifth instar). Diapause occurs in the third instar, and may occur under natural conditions of food deprivation (in August) or on the approach of winter (in late November). Laboratory experiments indicate the winter diapause may be triggered by short-day photoperiod.

5. Pupation occurs at some distance from the host plant on which the larva fed. The pupae vary in color from pure white to almost black.

6. Newly emerged males are ready to mate the same day of emergence, but females must mature for one or two days prior to mating.

7. Parasites and predators discovered to date are discussed.

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NOTES ON *LETHE CREOLA* (SATYRIDAE), WITH DESIGNATION OF LECTOTYPE

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Despite its occurrence in populous and long-settled parts of the United States, *Lethe creola* (Skinner) remains a comparatively obscure and little-known butterfly, poorly represented in most collections. Several factors may share responsibility for this. *L. creola* is very local, and of crepuscular and retiring habits, so that it may well be overlooked where it occurs. There has been much confusion of *creola* with its congener *L. portlandia* (Fabr.) which it closely resembles in the female sex. In fact, Gillham and Ehrlich (1954) found that the female paratype of *creola* was itself actually *portlandia*. The conflicting and erroneous records of the species and descriptions of its range which have appeared in the literature have contributed their share to the problems which surround it. Further, the lack of an adequate figure of the female *creola* in the popular literature has probably resulted in the inability of many collectors to recognize it.

During the preparation of a forthcoming checklist of the butterflies of Illinois, it became desirable to verify the reported occurrence of *L. creola* in that state. This investigation quickly developed into a much more extensive study of the species as a whole, taking into account its taxonomy, characters and distribution. It is hoped that this paper may clear up some of the problems above outlined.

Taxonomy

Skinner (1897) described *Debis creola* from specimens sent to him "by Mr. G. R. Pilate, who captured them at Opelousas, Louisiana, on July 3rd, present year." The number of specimens comprising the type series is not stated, nor are holotype, allotype or paratypes designated. In 1926, however, Skinner referred to the "type" and "allotype" of *creola* as being the only examples of the species which he had actually seen, thus clearly indicating that they were the only specimens before him when he wrote his description of *creola*. Mr. Harry Clench, with whom I have discussed the taxonomy of *creola* at length, believes that Skinner's statement (1926), in conjunction with the labels of these two specimens, might be considered a lectotype designation. He suggested the propriety, however, of making a formal selection of a lectotype for *creola* in order to remove any ambiguity which might still exist from Skinner's actions.

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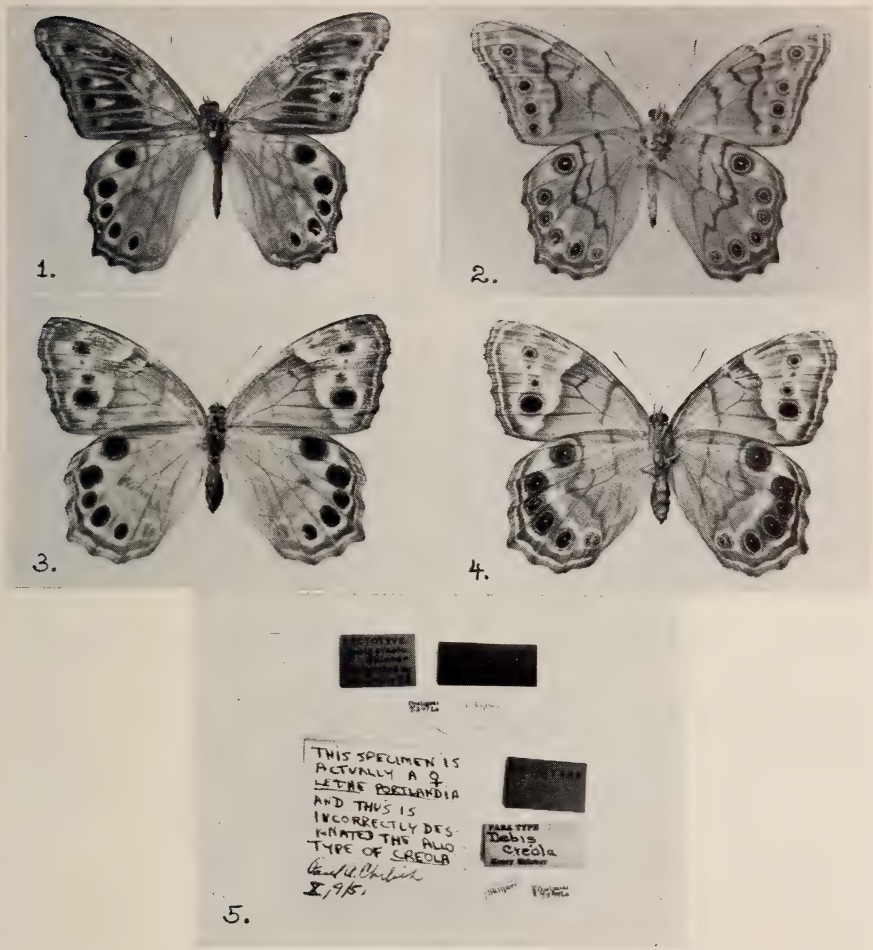
The two members of the type series are in the Skinner Collection in the Carnegie Museum. These are a male, labelled "type" but which has not been so designated in accordance with the Code, and a female, which is actually a specimen of *L. portlandia*. I designate the male specimen, labelled "Skinner" (white paper, letterpress; "Opelousas/7/3/97 La" (white paper, letterpress; date in black pen); "TYPE NO. 7039/Debis/creola/Henry Skinner" (red card; letterpress with species name in black pen) as the lectotype of *Debis creola* Skinner. I have placed an appropriate label, reading "LECTOTYPE/Debis creola/♂ Skinner/Designated by/R.R. Irwin '69" (red card; black pen) on the pin of this specimen.

The taxonomy of this species is complicated by the fact that Skinner's female "type" of *creola* has been found by Gillham and Ehrlich (1954) to be a female of *L. portlandia*. Mather and Mather (1958) discuss this finding in detail.

In addition to the type specimens, the two examples which Holland used as models for his figures of *creola* in the "Butterfly Book" are in the Carnegie Museum. They are apparently members of the "type lot," but cannot be considered syntypes since there is no evidence that they were ever before Skinner, most probably having been transmitted directly by Pilate to Holland. It may be assumed, in fact, from Skinner (1926) that he saw only the illustrations of Holland's specimens. The case of these two specimens is analogous to that of the types with respect to specific identity. Clench (*in litt.*) has found that the specimen which Holland used to illustrate the female of *creola* is, like the female paratype, actually *L. portlandia*.

Characters

The recognition of male *creola* presents no difficulty; the apically produced forewing and patches of dark, raised androconial scales between the veins are unmistakable. It is in the opposite sex that identification problems arise. In wing shape and other respects, female *creola* strongly resembles the female of typical *L. portlandia portlandia*, the subspecies of the southeastern states. Most authors mention characters based upon the relative size and number of the ocelli on the ventral forewing. A study of long series of both species has convinced me that these are of little value. They hold true for the majority of examples of both species, but enough individual variation occurs to reduce sharply the usefulness of such characters. For example, I have seen specimens of *L. portlandia anthedon* (Clark) exhibiting five well-developed ocelli, the number also possessed by *creola*; in these, the ocellus below vein Cu_2 was fully equal in development to the others. Forbes (1960) ignores characters based on the [illegible] and mentions only the single character which appears to hold



Figs. 1–5. 1, Lectotype of *Debis creola* Skinner, upper side; 2, same, lower side; 3, ♀ paratype of *Debis creola* Skinner, upper side (actually a ♀ of *L. portlandia*; see text); 4, same, lower side; 5, labels of the above specimens. Those above the wavy line are of the lectotype; those below it, of the paratype.

All photos by Mr. Allan Watson, Department of Entomology, British Museum (Natural History); specimens in Carnegie Museum collection.

constant in the female sex: the shape of the postmedian line on the underside of the primaries. In *creola*, this line is irregular and protrudes strongly outward in cell M_1, while in *portlandia* it is relatively straight. This character is even more pronounced in the female than in the male, as shown by comparison of the underside of the male (Fig. 2) with that of the female (Fig. 7).



Figs. 6, 7. 6, *Lethe portlandia portlandia* (Fabr.) ♀ New Berne, N. C., leg. S. Strecker (Strecker Collection), lower side; 7, *L. creola* (Skinner) ♀ Stewart County, Georgia (Strecker Collection), lower side.

Arrows locate the postmedian line which is the most reliable character for the separation of *portlandia* and *creola* in the female sex; see text. (Photos by Field Museum of Natural History.)

Distribution

This study was inspired not only by the need to verify the occurrence of *creola* in Illinois, but by the memory of my years of fruitless search for the butterfly in well-collected areas from which it had been reported, principally Palos Park, Illinois, and southern Michigan. The results of my investigation indicate that not only is the actual range of *creola* considerably less extensive than most present-day butterfly manuals suggest, but that it is very probably limited by host plant association. It is apparent, too, that it possesses a continuous range, rather than a disjunct one as indicated by published reports. The range of *creola* given by Klots (1951) is typical of these: "Manitoba, Illinois, Michigan, eastern Virginia s. to Texas, Louisiana, Florida (rare)." Again, Forbes (1960) seems to have had a more nearly correct concept of its distribution when he described it as "In the Mississippi Valley north to Illinois, in the east not seen beyond the Dismal Swamp in Virginia."

While so far as I have been able to determine, the life history of *creola* has not been worked out, all available evidence indicates that the host plants are species of Cane (*Arundinaria*), particularly Switch Cane (*A. tecta*). Canes are restricted to the southeastern and south central portions of the United States, south of approximate latitude 39°, and west to eastern Texas, Oklahoma, and possibly extreme southeastern Kansas. Records of *creola* from outside this area were critically examined; most were found to be erroneous. These include the widely quoted records from Manitoba, Michigan, and Palos Park, Illinois. (The Illinois state record may be retained, however, as recently true *creola* has turned up in

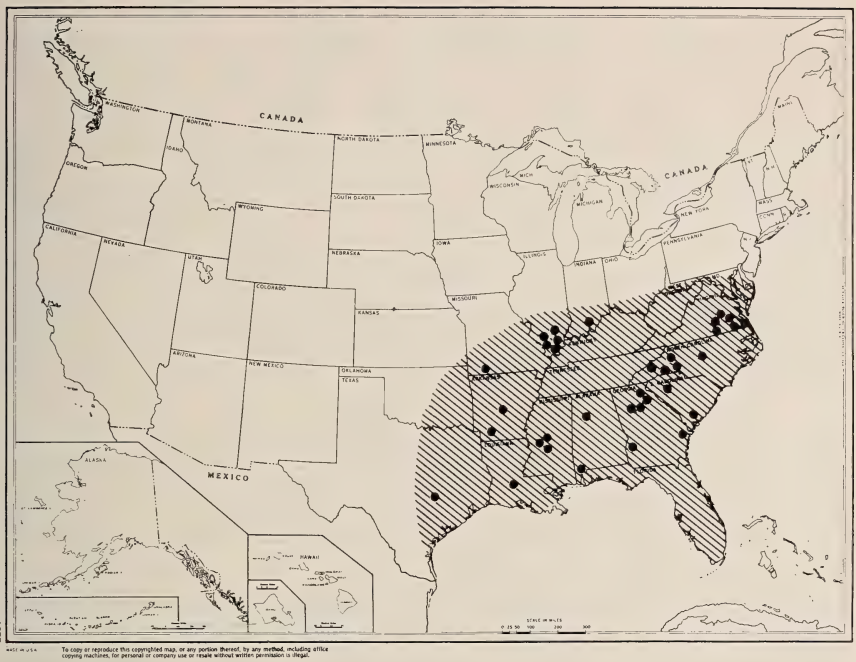


Fig. 8. The distribution of *Lethe creola* as compared to that of its putative foodplant, *Arundinaria* species. Shaded area represents the range of *Arundinaria* in the United States; the dots represent localities from which *Lethe creola* has been authentically recorded. In Virginia, each dot represents a county from which *creola* has been recorded; elsewhere, each separate locality is shown, except for additional records received too late for inclusion on the map; see text.

several localities in extreme southern Illinois.) Records from Kansas (Randolph, 1929) and Florida (summarized by Kimball, 1965) remain in doubt because it was not possible to locate and verify the identity of all specimens referred to in these papers.

Dr. C. L. Remington (*in litt.*) makes the following very interesting statement, which does much to explain the confusion of *creola* and *portlandia*: "There is a general myth around that far-southern specimens which look quite different from the usual more northern *portlandia* must be *creola*. The great Louisiana collector for many years was F. R. Arnhold, and he was under this misunderstanding and sent large numbers of Louisiana *portlandia* to collectors all over the country under the *creola* label. We in fact have many of these in the Arnhold collection, now at Yale, and my father [P. Sheldon Remington] had some." In view of Remington's statement, therefore, all Arnhold "*creola*" from Louisiana ought to be viewed with suspicion, and their determinations rechecked

by whomever may possess them in their collections. Ross and Lambremont (1954) mention these Arnhold "*creola*" from Louisiana, which are now known to be *portlandia*. The types and the Holland specimens remained the only Louisiana records until recently, when Mr. Gayle T. Strickland of Baton Rouge took several specimens in West Feliciana and East Baton Rouge parishes. His records, unfortunately received too late for inclusion on the distribution map, were authenticated by Messrs. Richard Heitzman and Bryant Mather.

With the elimination of the definitely and probably erroneous records of *creola* discussed above, all other localities known to me for the species are seen to fall well within the range of the species of *Arundinaria*. These are indicated in the map (Fig. 8), and are based either upon material which I have examined, or records which I consider entirely reliable. These localities are summarized below. In addition to Strickland's Louisiana records, that from Fayetteville, in northwestern Arkansas, was received too late for inclusion on the distribution map. Heitzman and Dr. Leo J. Paulissen have just informed me (*in litt.*) that *creola* is well established near that city.

The stronghold of the species would appear to be the Dismal Swamp area of southeastern Virginia (Clark and Clark, 1939; 1951), but positive differentiation of the species from *portlandia* may well prove it to be commoner elsewhere in its range than previously suspected. This range may be defined as follows: from eastern Virginia and southern Illinois south and west, to and including eastern Texas, Louisiana, Arkansas and southern Missouri. The species is thus seen to be of Lower Austral affinities, as is its probable host plant, and its occurrence beyond the limits of that subregion, or outside the range of *Arundinaria*, must be regarded as unlikely or accidental.

Summary of Distributional Records for *Lethe creola*

I list below, by state and county, all localities known to me from which *Lethe creola* has been authentically recorded. All are shown on the map (Fig. 8), with the exception of those marked *. Virginia records are indicated on the map by county only because of the number and closeness of localities in that state. Abbreviations used are as follows: AMNH = American Museum of Natural History; FMB = F. M. Brown; CNC = Canadian National Collection; RLC = R. L. Chermock; AHC = A. H. Clark; CFdP = C. F. dos Passos; DE = Donald Eff; FMNH = Field Museum of Natural History; FDPI = Florida Division of Plant Industry; HAF = H. A. Freeman; LH = Lucien Harris, Jr.; RH = Richard Heitzman; INHS = Illinois Natural History Survey; MCN = M. C. Nielsen; LJP

= L. J. Paulissen; GWR = G. W. Rawson; SIU = Southern Illinois University; GTS = Gayle T. Strickland; USNM = United States National Museum; Yale = Yale University.

ALABAMA: Mobile, Mobile County; Tuscaloosa, Tuscaloosa County (RLC).

ARKANSAS: Magnolia, Columbia County (RH); North Little Rock, Pulaski County (HAF); west of Little Rock, Pulaski County (LJP); Fayetteville, Washington County (RH)*.

GEORGIA: Savannah, Chatham County (DE); Athens, Clarke County; Stone Mountain, De Kalb County; Atlanta, Fulton County (LH); Stewart County (Strecker Collection, FMNH); Yonah Mountain, White County (LH).

ILLINOIS: Benton, Franklin County; Murphysboro, Jackson County; Lusk Creek near Eddyville, Pope County; Stonefort, Saline County (SIU); Pine Hills, Union County (INHS, SIU).

INDIANA: Patoka River near Valeene, Orange County (Masters and Masters, 1969).

LOUISIANA: Baton Rouge, East Baton Rouge Parish (GTS)*; Opelousas, St. Landry Parish (type locality); Weyanoke, Retreat, West Feliciana Parish (GTS)*.

MISSISSIPPI: Clinton, Brownsville, Hinds County; Natchez Trace Cypress Swamp, Madison County (Mather and Mather, 1958).

MISSOURI: Hollister, Taney County (Kite, 1934).

NORTH CAROLINA: Gastonia, Gaston County (RLC, USNM); Fontana Village, Graham County (MCN); Hendersonville, Henderson County (FDPI); Southern Pines, Moore County (FMB); Wilkesboro, Wilkes County (AMNH).

SOUTH CAROLINA: Greenville, Greenville County (AMNH); Coosawhatchie, Jasper County (CFdP, AMNH, Yale).

TEXAS: "Texas" collected by L. Heiligbrodt (Strecker Collection, FMNH). This may be the "aberration a" of *L. portlandia* described by Strecker (1878); probably from Bastrop, Bastrop County, where Heiligbrodt lived and collected (Brown, 1964).

VIRGINIA: Bog near Petersburg, Dinwiddie County (AHC); near Emporia, Greensville County (AHC); Zuni, Isle of Wight County (AHC); near Adam's Swamp (AHC), Dismal Swamp near Suffolk (AHC, AMNH, CNC, CFdP), Nansemond Escarpment (AHC), Suffolk (GWR, CFdP, FMB, FMNH), and Raly Pocoson (USNM, FMNH), all in Nansemond County; New Bohemia, Prince George County (GWR, AHC); Creeds, Princess Anne County (AHC).

Acknowledgments

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THE LIFE HISTORY OF *EUTRICOPIS NEXILIS* (NOCTUIDAE)

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Entomology Research Institute, Canada Department of Agriculture, Ottawa, Ont.

Eutricopis nexilis Morrison (1875, p. 102) feeds in the larval stage on the heads of species of *Antennaria*, a complex genus of the Compositae, that is widespread in temperate North America. The insect itself is also widespread. In Canada, it is distributed from Nova Scotia to south-central Ontario, and from southern Saskatchewan to southern British Columbia. There is an apparent hiatus in its distribution through western Ontario and southern Manitoba. In western North America, the species is distributed southward at least as far as Colorado. In western Quebec, *nexilis* flies during May; with increasing elevation in the west, however, the period of adult activity is progressively retarded, and at an altitude of 6,000 feet in southern British Columbia, the flight period may be protracted into the first part of August.

Eastern and western populations differ in both adult and larval characteristics. Eastern adults are distinguished from western adults by a less patchy appearance of the dark areas of the forewing and by a reduction in the extent of the white areas on both fore- and hind wings. Moreover, representatives of eastern populations are significantly smaller at the one percent level than their western counterparts, the mean expanse for eastern material being 16.2 ± 1.1 mm[1] (24 specimens) in

[1] Standard deviation

contrast to 18.5 ± 1.1 mm (60 specimens) for western material. The larvae of eastern specimens are similarly smaller than western larvae, and most noticeably so in the last stadium. The time required for larvae to complete their growth is also significantly shorter among eastern individuals than among western individuals. The mean duration of the feeding phase of the larval stage of specimens reared from Hull, Quebec was 15.0 ± 0.9 days (18 larvae) and from Keremeos, B.C. 21.3 ± 2.9 days (12 larvae). The two are significantly different at the one percent level.

On the basis of differences in both larvae and adults, eastern and western populations of *Eutricopis nexilis* might be considered as representing different subspecies.

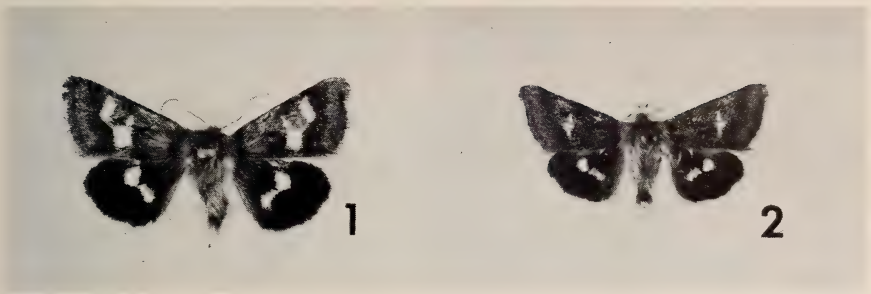
Behaviour

Eutricopis nexilis is an exclusively day-flying species, and has the greatly reduced compound eyes that are commonly associated with this period of activity. The little moth flies very quickly and the patchy dark and white pattern of both fore- and hind-wings makes it almost impossible to keep the insect in view. In the cooler parts of the day and during cloudy periods, adults of the species commonly rest on the flowering heads of the food plant.

The eggs are deposited singly among the florets of *Antennaria*, the female forcing her abdomen down through the head from the top to oviposit above the developing seeds. For a noctuid moth of such small size, *E. nexilis* deposits an extraordinarily large egg. The pattern of depositing such a large egg is one that has evidently developed within some of the smallest heliothidine moths to insure the survival of their progeny (for discussion, see Hardwick 1969). The fecundity is correspondingly low; five wild-caught females, taken at Hull, Quebec, deposited a mean of 7.8 eggs, and the maximum laid by any individual female was ten. A majority of the eggs observed, hatched on the fourth day after deposition.

The newly hatched larva feeds first on the florets, then on the developing seeds. First- and second-stadium larvae show very characteristic external evidence of their feeding within a head. One to several florets are severed at their junctures with the seeds and the florets are pushed outward so that they protrude above the general surface of the head. Usually during the third stadium, the larva quits the first head and enters a second, making its way downward through the top of the head toward the seeds.

Third- and fourth-stadium larvae also give typical external evidence of their presence within a head. All of the florets are severed from the



Figs. 1, 2. *Eutricopis nexilis* Morr. 1, Nickel Plate, Hedley, B.C., 6,500 feet; 2, Mt. St. Hilaire, Que.

seeds and pushed outward and a tangled mass of florets and pappi are left protruding from the receptacle (Fig. 3). The mass does not seem to become dislodged from the plant, however, and it may be secured into position by strands of silk. The larger larva thus fashions a nest for itself within the receptacle so that it may remain concealed while feeding on the seeds.

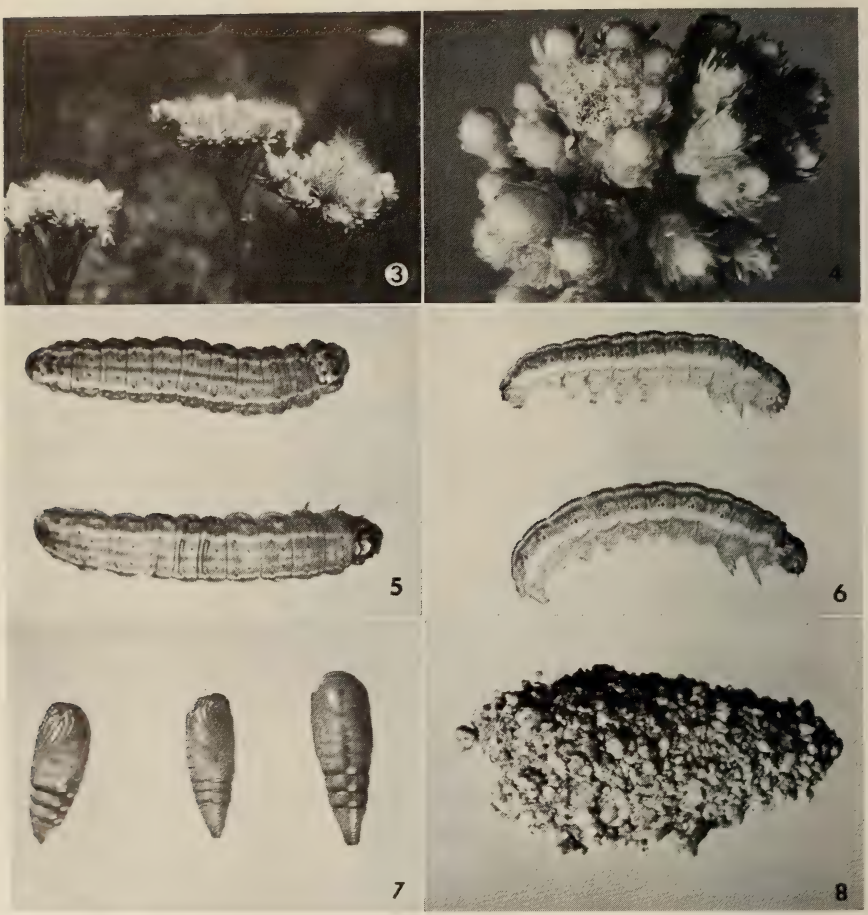
Larvae mature in four stadia. At the cessation of feeding, the larva makes its way to the ground and fashions an elongate cocoon or pupal cell whose walls are formed of granules of soil and bits of organic débris (Fig. 8). The pupal cell is formed at or immediately below the surface of the ground. In one case observed, the larva on ceasing to feed, actually formed a pupal cell among the heads of its food plant (Fig. 4).

So far as is known, *Eutricopis nexilis* is entirely single-brooded throughout its range. It overwinters as a pupa in the earthen cell at the surface of the ground.

Descriptions of Stages

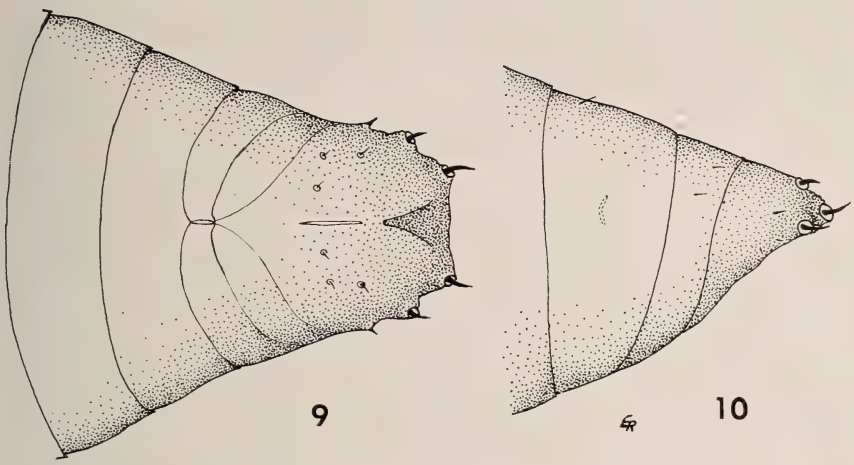
Data on the immature stages of *Eutricopis nexilis* are based on rearings from three localities: Aylmer, Quebec; Twin Lakes, Keremeos, B.C., 4,700 feet; and Osoyoos, B.C., 4,000 feet. The durations of stadia listed are those obtained from rearings maintained at room temperature. Rearing techniques employed were the same as those outlined by Hardwick (1958). The estimate of variation, following the means for various measurements, is the standard deviation.

Adult (Figs. 1, 2). Vestiture of body consisting of black, closely appressed scales overlaid by elongate, yellowish-grey or olive-grey, hair-like vestiture; overlying vestiture of abdomen usually not heavy. *Forewing* olive-grey, marked with pale yellow or white and suffused with red. Basal space broad, extending outward to incorporate all of orbicular spot; usually a narrow, pale-yellow or white triangle in anterior region of basal space marking the proximal margin of orbicular; basal space variably overlaid and suffused with dark red, most strongly so anteriorly and outwardly; red suffusion occasionally so extensive as to obscure any olive-grey colouring.



Figs. 3–8. *Eutricopis nexilis* Morr., immature stages and damage. 3, Tufting of florets of *Antennaria* sp. caused by larval feeding; 4, an unusual cocoon formed in the head of *Antennaria* sp.; 5, dorsal aspect of fourth-stadium larvae; 6, right lateral aspect of fourth-stadium larvae; 7, pupae; 8, pupal cell.

Median space pale yellow or white, very narrow because of enlargement of basal spaces; anterior half of median space containing a large, dark, usually rectangular, reniform spot; pale central area of median space often separated from margins of wing by a dark band along costal margin and another along trailing margin. Transverse posterior line usually smoothly biarcuate. Subterminal line irregular, marked only by colour change between subterminal and terminal spaces. Subterminal space shades of red or reddish-brown, rarely olive. Terminal space olive-grey. Fringe usually white or pale grey, occasionally concolorous with terminal space. *Hind wing* dark blackish-brown with two white central spots; central spots often coalescing to form an irregular white central band. Fringe white. *Underside of forewing* with a pink or brown basal space in which orbicular and claviform spots often well defined. A white median band containing a large, dark-brown discal spot. A broad dark-



Figs. 9, 10. Apical abdominal segments of pupa. 9, Ventral; 10, left lateral.

brown, outer-marginal band extending forward from outer angle almost to apex. A white patch, margined proximally with pink, at apex of wing. Fringe brown at apex, otherwise white. *Underside of hind wing* with a brown patch at anal angle and a brown suffusion along inner margin. Anterior half of wing white or pale grey variably suffused with pink. Two white central spots or an irregular central band. Fringe white with a brown basal line.

Expanse: Eastern populations, 16.2 ± 1.1 mm (24 specimens); western populations, 18.5 ± 1.1 mm (60 specimens).

Egg. Very pale greenish-yellow when deposited; darkening gradually in the next three days first to a dark yellow and then to a dull orange. Micropylar half of egg becoming brown on the third day after deposition. Entire outline of larva visible through chorion within a few hours prior to hatching.

Dimensions of egg: 0.854 ± 0.019 mm × 0.539 ± 0.019 mm (3 eggs).

Incubation period: 4.4 ± 1.0 days (25 eggs).

First-Stadium Larva. Head black. Prothoracic and suranal shield medium to dark grey. Trunk pale translucent yellow, often with a strong internal orange suffusion.

Head width: Keremeos, B.C., 0.361 ± 0.013 mm (9 larvae); Hull, Que., 0.353 ± 0.014 mm (16 larvae).

Duration of stadium: Keremeos, B.C., 3.2 ± 1.8 days (12 larvae); Hull, Que., 3.9 ± 0.8 days (18 larvae).

Second-Stadium Larva. Head black. Prothoracic and suranal shields dark brown. Trunk varying from ashen grey to yellowish grey. Setal bases, thoracic legs and rims of spiracles dark brown.

Head width: Keremeos, B.C., 0.568 ± 0.025 mm (26 larvae); Hull, Que., 0.557 ± 0.022 mm (16 larvae).

Duration of stadium: Keremeos, B.C., 3.8 ± 0.6 days (12 larvae); Hull, Que., 2.2 ± 0.6 days (18 larvae).

Third-Stadium Larva. Head light to medium brown, variably suffused and mottled with dark brown; dark suffusion often so prevalent as to obscure any paler colouring. Prothoracic and suranal shields usually paler than head, brown, mottled with darker brown; prothoracic shield usually with one or two pairs of pale longitudinal lines. Trunk light to medium grey, usually with a strong greenish tone; a

middorsal and a pair of subdorsal brownish longitudinal bands often evident. Rims of spiracles brown. Proleg shields concolorous with trunk. Setal bases and thoracic legs medium to dark brown.

Head width: Keremeos, B.C., 0.924 ± 0.037 mm (25 larvae); Hull, Que., 0.846 ± 0.051 mm (18 larvae).

Duration of stadium: Keremeos, B.C., 4.7 ± 1.0 days (12 larvae); Hull, Que., 3.4 ± 0.8 days (18 larvae).

Fourth-Stadium Larva (Figs. 5, 6). Head pale yellowish-fawn or greenish-fawn, variably mottled and suffused with chocolate-brown dorsally and in centre of face; head often only weakly marked with brown. Prothoracic shield fawn marked with dark brown, usually more heavily marked than head; with a pale-yellow middorsal line and a pair of paler-yellow sublateral bands. Suranal shield fawn marked with black. Middorsal band varying from reddish-brown to purplish-red. Subdorsal area consisting of a dark median band and pale marginal lines, the dorsal marginal line commonly evanescing; median band of subdorsal area varying from a reddish-brown, paler than that of middorsal band, to a medium green with a faint pink suffusion. Supraspiracular area similar in color to median band of subdorsal area; with an irregular and discontinuous, pale greenish-yellow median line passing through it. Spiracular band greenish-grey, poorly distinguished from suprapodal area. Suprapodal and midventral areas concolorous, varying from greyish-green to apple green. Proleg shields concolorous with suprapodal area. Setal bases and rims of spiracles dark blackish-brown. Thoracic legs medium brown.

Head width: Keremeos, B.C., 1.482 ± 0.073 mm (12 larvae); Hull, Que., 1.354 ± 0.076 mm (25 larvae).

Duration of feeding phase of fourth stadium: Keremeos, B.C., 9.7 ± 2.6 days (12 larvae); Hull, Que., 5.4 ± 1.2 days (18 larvae).

Duration of prepupal phase of fourth stadium: Keremeos, B.C., 6.2 ± 3.2 days (9 larvae); Hull, Que., 4.7 ± 0.7 days (12 larvae).

Pupa (Figs. 7, 9, 10). Uniform light yellowish-brown. Rims of spiracles on a level with general surface of cuticle. Anterior marginal areas of abdominal segments 5, 6 and 7 only weakly pitted. Apex of wing extending posterior to apex of proboscis. Apex of tenth abdominal segment dorsoventrally flattened and with a truncated posterior margin; with a pair of conspicuous, short, stout setae on either side; an additional, smaller, lateral seta anterior to the conspicuous pair; also a pair of subapical dorsal setae.

Length to posterior margin of fourth abdominal segment: Keremeos, B.C., 4.81 ± 0.60 mm (16 pupae); Hull, Que., 4.05 ± 0.32 mm (4 pupae).

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I am grateful to Mr. John E. H. Martin of this Institute for assistance in the field and for the fine photographs accompanying this paper. I appreciate the assistance of my associate, Mr. E. W. Rockburne who measured the immature stages and drew the cremaster area of the pupa.

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THE MIGRATIONS OF THE PAINTED LADY BUTTERFLY, *VANESSA CARDUI* (NYMPHALIDAE), WITH SPECIAL REFERENCE TO NORTH AMERICA

C. B. WILLIAMS
Elm Park Lodge, Selkirk, Scotland

The nymphaline butterfly *Vanessa* [or *Pyrameis*] *cardui* Linn., known in Britain as the "Painted Lady" or "Thistle" butterfly, and in France as "La Belle Dame", is probably the most widely distributed of all butterflies. It is found, at some time of the year, in every continent except South America, where it is rare or absent (see Fig. 1).

In Australia, New Zealand and some of the Pacific Islands there is a form *kershawi* which has slight differences in structure and wing markings, and has sometimes been considered as a distinct species. Apart from this the Painted Lady is very free from local variation in form or colour. Specimens from Japan, India, South Africa, Europe and N. America are indistinguishable. Such widespread uniformity is an indication of the constant intermingling of populations, and is characteristic of many other insects which migrate with wide distributions.

In the great land mass of Europe, Asia and Africa, it ranges, according to the season, from the tropics northwards to within the Arctic Circle and southwards to the limit of the land. In South Africa this is about latitude 43° S. In southern India and Ceylon about 10° N and in the East Indies about 10° S. The Australian form reaches nearly 44° S in New Zealand and Tasmania.

Ecologically the Painted Lady prefers drier and more open country and in the tropics is more often found on higher and drier land. It is never common in the wet tropical forest, which may account for its absence in most of S. America.

Over the greater part of its range in temperate climates it is not a permanent resident, and, unlike most of the Nymphalidae, seems unable to survive cold winters in any stage. As a result, such areas depend for their

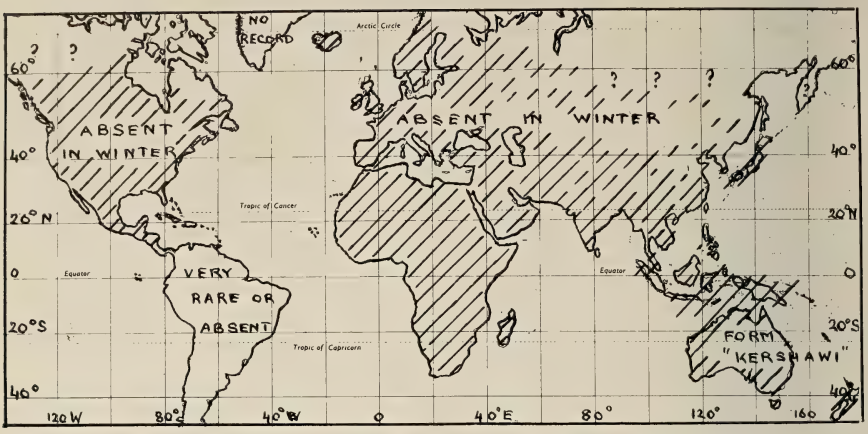


Fig. 1. The world distribution of the Painted Lady, which is found, at one season or another, in almost all parts of the world except South America.

Painted Lady population on migratory flights from the more permanent habitats in the warm-temperate and subtropical climates.

In Western Europe and North Africa, where its occurrence has been studied for many years, there appears to be very little winter survival north of the Mediterranean. Each spring there is a northward movement, sometimes very small, sometimes in immense numbers, spreading from North Africa, and even from across the desert area further to the south.

In the north the butterflies reach Iceland in some years, and have been recorded beyond the Arctic Circle in Scandinavia and Finland. The main immigration into the British Isles occurs about the end of May or June, but sometimes earlier. The immigrants lay eggs and local-bred butterflies appear about August. Further south in Europe, there may be two or more generations before the fall. There is no evidence of any winter survival, but there is increasing evidence of a return flight to the South in the fall on a much smaller scale than the northward flight in the spring. This southward movement is difficult to observe in Britain, but appears to augment in numbers as it goes south, and quite definite flights have been seen crossing the Pyrenees in September and October. Still further south I have seen (in late Sept. 1943) a very extensive southward flight over the Atlantic between southern Spain and the westward bulge of North Africa.

In eastern and southern Africa the Painted Lady is widespread and there are records of large numbers making sudden appearances and sometimes of definite directional flights. In Ghana and Nigeria records of abundance are chiefly in September and October.

In the East, as far as the Caspian Sea, there are many records of north-

erly spring migrations, and a very large flight has been observed crossing the Shandur Pass in Chitral at 16,000 feet.

Still further east and as far as Japan I have found no direct information of seasonal movement, but it may well occur without being noticed.

In Australia the form *kershawi* is uncertain in appearance and has at times been observed in mass flights similar to those in the northern hemisphere. There is also a possibility that the population in New Zealand may occasionally be reinforced by flights across the 1200 miles of sea which separates it from Australia.

There are, in addition to the cases mentioned above, many records of the butterflies far out to sea. In the North Atlantic there is a remarkable record of several being seen in 1865 on a steamer about half way between Iceland and Newfoundland, and another record in 1950 of several being seen on the tropic line more than half way across the Atlantic between the Mediterranean and the West Indies. I have also one captured about 500 miles from land in the Indian Ocean. These are probably individuals which have been blown out of their normal routes by strong wind currents.

Food Plants and Life Cycle

The caterpillars of the Painted Lady have been recorded on over a hundred different food-plants, in many different orders, but chiefly the Malvaceae, the Compositae and the Leguminosae. A number of plants of economic importance are included. In subtropical regions of Eurasia they frequently destroy the leaves of *Malva parviflora* (Khoubeiza in Egypt), which is an important vegetable food, and in Eastern Europe (Yugoslavia) they can be quite serious pests of maize, lucerne, beans, sunflowers, and soya-beans. On the other hand, their great preference for thistles in temperate countries, such as the northern U. S. A. has made them welcome visitors there in grazing country.

Little is known of their seasonal life-cycle in the tropical countries, but in Europe and North America there appear to be one or two broods during the period of summer residence. The Painted Lady shows no ability to enter into a definite resting stage (diapause) or to be able to survive a cold winter in any stage.

The Seasonal Distribution of the Painted Lady in North America

Summer Distribution: In the summer months *Vanessa cardui* may be found breeding in any part of the United States from the Pacific to the Atlantic. It is more irregular in appearance in the northeastern States; and is not often recorded in the southeast, though if this is due a real rarity or



Fig. 2. The approximate summer and winter distribution of *V. cardui* in North and Central America.

lack of interest is not certain. It may here be confused with *V. virginiensis* Drury which is generally more common.

In Canada it is known to breed in the southern portions of all the provinces from British Columbia to Newfoundland. In the latter it is sporadi-

cally quite common. In the extreme north, adults have been seen on the Labrador coast, and in the Northwest Territories at Chesterfield Inlet on Hudson Bay, in north latitude 64°. This is nearly as far north as Iceland to which the migrant Painted Ladies from the European fauna occasionally stray. Adults have also been captured on Great Slave River in the Mackenzie District at about 60°30′ N.

I have no records from northern British Columbia or from the Yukon, although I would have expected it to go at least as far north in the west as in the east, particularly as the summer isotherms run farther north in the west. The only evidence for its occurrence in Alaska is that W. H. Edwards in 1887 mentions it, without any details, in a list of butterflies known to occur there.

The Painted Lady also appears sporadically in numbers in the Bermuda Islands, about 600 miles east of South Carolina. The origin of these may be in the Antilles, to the south, but this is not certain.

Winter Distribution: In the winter months, by contrast, there is no evidence of survival in any stage in any part of Canada or the United States, except possibly in Florida, along the Gulf Coast, and more definitely in the extreme southwest of California, where breeding has been recorded in mid-winter.

In Mexico *V. cardui* appears to breed throughout the year, sometimes in abundance, but more records, including the months of activity are still needed. Still further south in the Central American States it becomes less common as the climate changes to the wet-tropical type. In Panama it is rare and in S. America almost unknown.

It occurs at times, and may breed, in most or all of the Caribbean Islands, but not on any scale of abundance that could account for the masses of the northerly spring migrations. In the most southerly island of the Antilles, Trinidad, it is a rarity. I know this from my own experience, as I lived in Trinidad for six years, and did not see one.

In the Hawaiian Islands in 20° N latitude, the same as that of Southern Mexico, one of the earliest records was reported by Blackburn in 1879. He stated that it was abundant in that year, though he knew of no previous record and had seen none before in his three years residence. Today it appears to be accepted as a regular breeding resident.

Pattern of Migration

The only solution that appears to fit our present knowledge is that the main, and perhaps the only, source of the parent swarms which invade N. America in the spring is to be found in those parts of Mexico, particularly in the northwest, which have a relatively dry climate. This area cor-

responds both in latitude and climate with the semi-desert parts of N. Africa which provide the main source of our European immigrants.

This would imply that the immigrants that appear fairly regularly in Newfoundland, or their parents, have their origin in western Mexico, nearly three thousand miles away.

Such mass movements could be carried out either by large numbers being blown by strong winds far out of sight at high altitudes, or by directional movements near the ground, possibly independent of the wind. For the former type of distribution we have at present no evidence, but this is not proof that it does not occur. For extensive movements at ground level evidence is steadily accumulating and a summary is given below.

Direct Evidence of Northward Spring Migration at Ground Level

Over the course of many years I have collected nearly 100 records of flights seen by naturalists in North America when the butterflies were all moving definitely in one direction. These vary from observations of a few dozen butterflies only, to one (quoted below) which was estimated to include 3000 million individuals. The characteristic, as in other migrant species and in other parts of the world, is a continued "purposeful" flight in a steady compass direction, apparently independent of the angle of the sun or the direction of the wind (see later). Such flights may last an hour or two, or go on for days and, though usually observed at a single locality, may cover a front of a hundred miles or more.

It might be interesting to quote here from E. A. McGregor's account (1924) of a gigantic movement of Painted Ladies to the north in California, to give an idea of a migration in its extreme form. He writes: "Continuing from 11th to 13th inclusive, there was a remarkable migration of this butterfly. All through the day there was an average of about 300 butterflies per acre at a given moment. The flight direction appeared to be from south-east to north-west.

"In travelling, the flight was not characteristic of butterflies in general, but was of a more steady and purposeful nature. During calm intervals the flight took place on an average of perhaps 10–20 feet altitude, but during the periods of windiness the butterflies flew very close to the ground. There appeared to be no attempt at pairing and the individuals flew well separated—possibly 10 feet apart on the average. It was very noticeable that they all pursued their flight in the same direction. It was rarely that individuals were seen to alight on vegetation but this they did at times.

"The above flight occurred at the warmest period yet experienced this

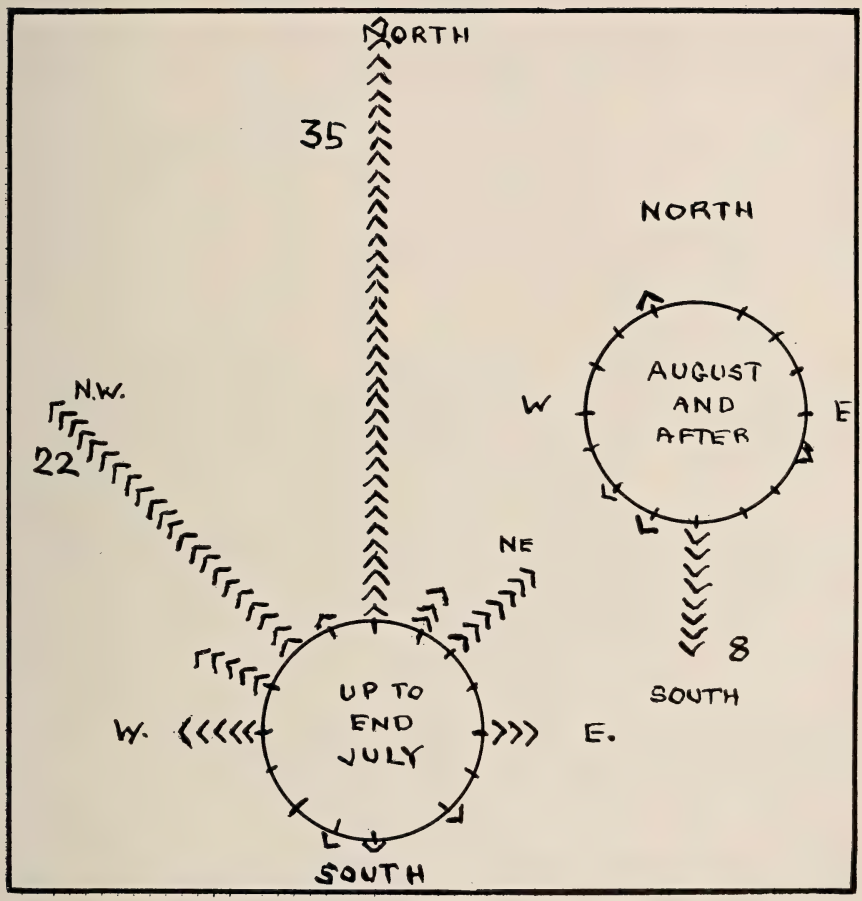


Fig. 3. Analysis of the direction of flight in nearly 100 recorded flights of migrating Painted Lady butterflies in North America, divided into those which occurred in the spring and early summer up to the end of July; and those which occurred in August and the fall. The records provide strong evidence for a large northerly flight in the spring, and a smaller return to the south in the fall.

season, temperature maximums ranging from 80–88° F. The temperature suddenly dropped late on the afternoon of the 13th, accompanied by a chilly wind, and the flight as suddenly terminated. On the 15th the temperature rose again, but a gusty wind occurred, so that only a few individuals could be seen migrating.

"An attempt to estimate the number of individuals comprising this three-day migration is here presented. The flight was estimated to

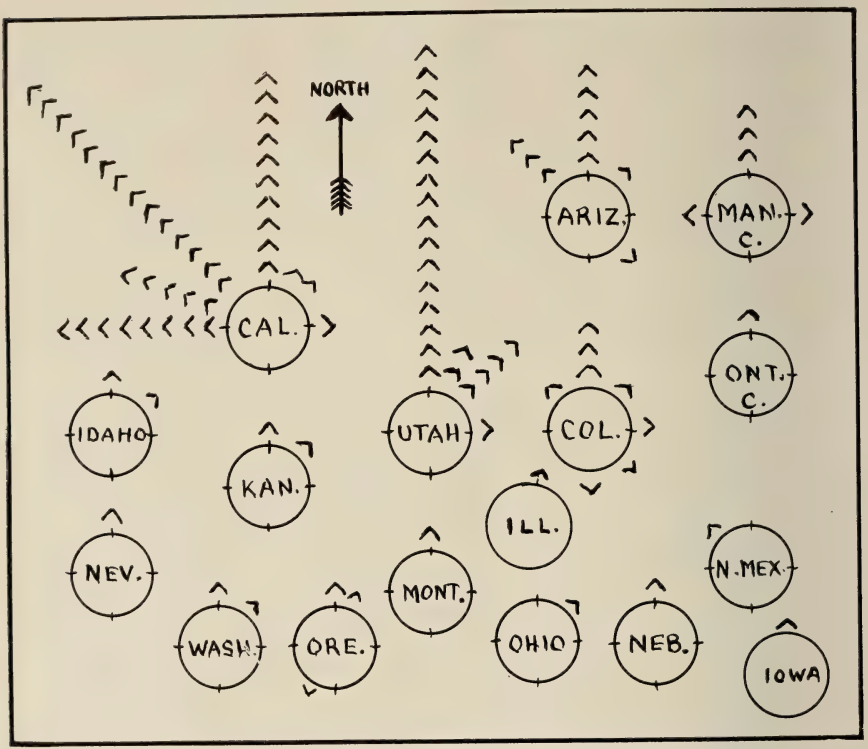


Fig. 4. The records of flights for the spring months, as detailed in Fig. 3, sorted according to the state or province in which they were seen.

have been at least forty miles in width (it no doubt was much wider). The daily duration of the migration was at least twelve hours, or a total for three days of thirty-six hours flight on any given point.

"Now the rate of travel was estimated at 12 miles per hour, which would give a total dispersion length of 432 miles for the three days. Within such a zone (40 miles by 432 long) is contained about 17,280 square miles or 11,059,200 acres. With the established occurrence of about 300 butterflies per acre, it is readily computed that at least 3,000,000,000 had passed on the 40-mile wide zone between Sunland and Lemon Cove."

To return to the evidence available for the northerly spring flight, Figure 3 shows a summary of the direction of movement in 96 recorded flights that I have been able to trace, arranged according to the time of the year. Of these, 84 occurred before the end of July (mostly from April to June) and these have an overwhelming trend to the NW, N, and NE quarter. Fig. 4 shows the same flights sorted according to the state or

province, and it will be seen that the NE component is almost completely accounted for by records west of the Rockies from California and Arizona. Records of spring flights in the middle and NE states are very few, and are completely lacking from the SE.

This northerly flight, at or near ground level in North America, has its exact counterpart in Europe, where we have hundreds of observations of such movements from the Mediterranean northwards; and also smaller numbers from northern Africa, and others at sea crossing the one to four hundred mile barrier of the Mediterranean Sea, or coming in to southern England across the Channel.

Evidence for a Southward Migration in the Fall

If North America is repopulated each year from the south, do all the offspring of the earlier immigrants die out before the fall, or is there a partial or general return to the south, to repopulate or replenish their winter headquarters?

Fig. 3B shows the very little evidence from North America that we have available on this point. There are only a dozen observations of flights after the beginning of August, and all but one of these have a southerly component, and eight of the twelve were said to be flying "to the south". The states and provinces, in which these flights were seen, are California (2), Colorado, Minnesota (several years, but no definite dates), New Jersey, New York, Florida, Ontario and Manitoba.

One of the most definite of these flights was seen by W. B. Henson at Sault Ste. Marie in Southern Ontario on the 30th Sept. 1949, and several days following. He estimated that 100 to 150 butterflies were crossing a ten-yard front every ten minutes over a front of at least a mile. This is equivalent to approximately 100,000 butterflies per hour on the observed mile. All the butterflies were flying to the south *across* a westerly wind.

It will be noted that many of these fall records are from the more easterly states, where mass flights in the spring are not so regularly recorded. This may perhaps be a psychological effect in that observers in the west are so satiated with Painted Ladies by the time the fall comes, that they cease to be interested.

The flight in Florida, referred to above, was that two *V. cardui* were captured by Mr. and Mrs. Hodges, along with several *V. virginiensis* in a long continued movement to the south of many species of butterflies in the fall of 1952. Further observations in this area are much needed.

As with the spring flight, the probability of a fall movement to the south in North America is supported by many records of a similar movement in Europe. My own observations of thousands of Painted Ladies

flying to the south far out at sea between Spain and the bulge of Africa in September 1943 has already been mentioned. The butterflies were very far apart, but the flight covered the whole fifteen hundred miles from off the mouth of the Mediterranean to the latitude of Sierra Leone, and was observed at all times of the day for eight successive days, and mostly fifty to a hundred miles from land.

Year to Year Variation in Abundance and Range

In some years the immigrant Painted Ladies and their larvae are abundant over most of the United States and southern Canada; in other years they may be so rare as to escape notice except in a few places. Such variations in numbers almost certainly reflect different weather conditions either in their winter breeding areas, or in the districts they pass through on their way north.

In the course of years I have collected between one and two thousand records of their presence (rare, common or abundant) in N. America in different years and in different areas. Table 1 shows a very condensed summary for the years 1900–1959, indicating when the immigration has been above average. It must always be remembered that "absence of evidence" is not the same as "evidence of absence"; and the further one goes back, the more frequently one is frustrated by the former state of affairs. In general there are more records of mass flights and unusual abundance west of the Rockies. There are however only a few records of either abundance or migration in Texas, which suggests that the immigration from Mexico is more concentrated in the western half of the country.

Figs. 5 and 6 show the constrasting conditions in the two consecutive years 1951 and 1952. In the former year there was scarcely a record of abundance anywhere, and an unusual number of cases commenting on its rarity or absence. By contrast, in 1952, the species was abundant in most of the Pacific States, with records of mass flights through the north-central and northeastern U. S. and the whole of southern Canada as far east as Nova Scotia, and as far north as Chesterfield Inlet (64° N) on Hudson Bay. There are however no records of abundance from Texas or from any of the Gulf States except Mississippi, where it was said to have been "abundant".

Possible Relation Between the Abundance of Immigrant Populations in Western Europe and North America

The history of the varying abundance of *V. cardui* from year to year in North America, given briefly in Table 1, makes it possible to compare the

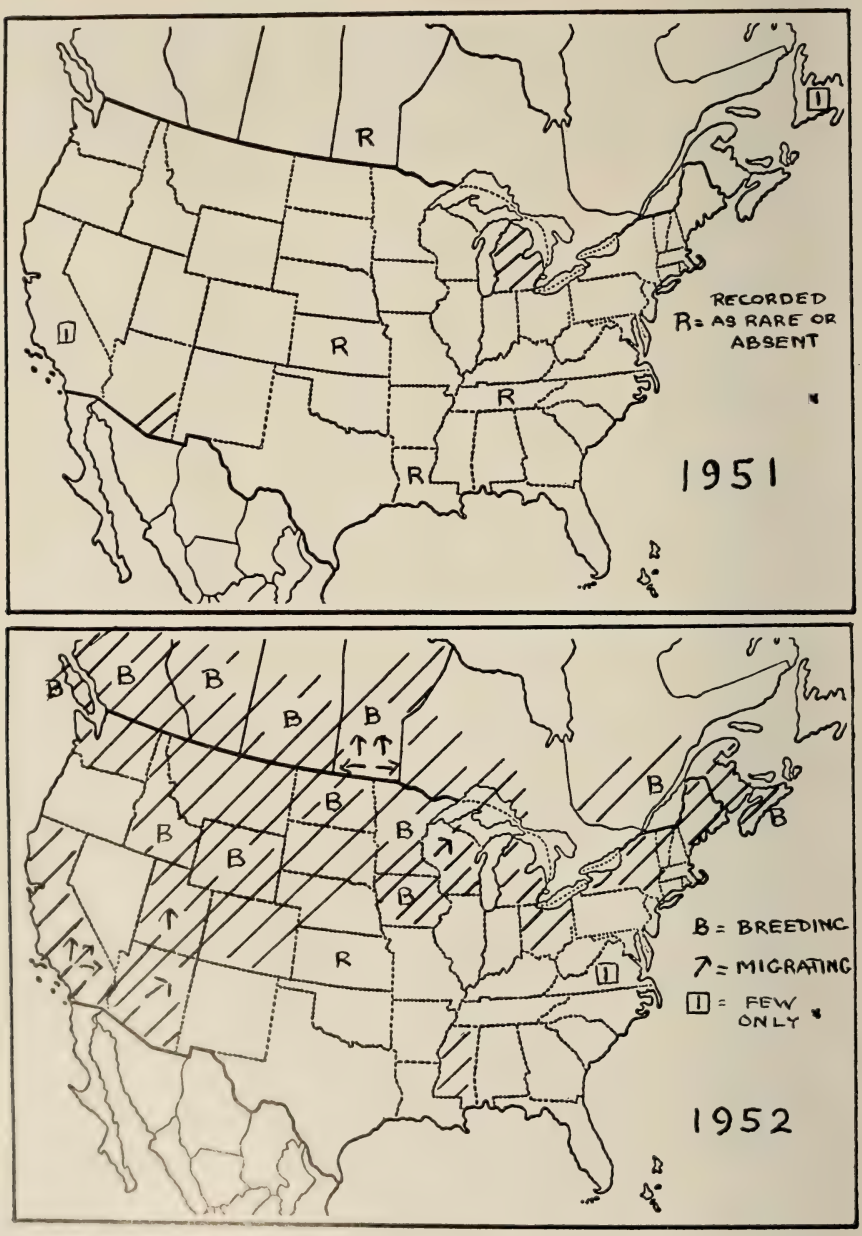
TABLE 1. THE YEARS BETWEEN 1900 AND 1959, IN WHICH, ACCORDING TO THE AVAILABLE EVIDENCE, THE PAINTED LADY BUTTERFLY WAS MORE THAN USUALLY COMMON (C) IN NORTH AMERICA AND IN BRITAIN

	Brit.	N. Am.		Brit.	N. Am.		Brit.	N. Am.
1900	c	c	1920	c	c	1940	c	c
01	–	c	21	c	–	41	c	c
02	c	c	22	c	–	42	–	–
03	c	–	23	c	–	43	c	–
04	c	c	24	–	c	44	–	–
05	–	–	25	c	–	45	c	c
06	c	–	26	c	c	46	c	c
07	–	c	27	c	–	47	c	c
08	c	–	28	c	–	48	c	–
09	–	–	29	–	–	49	c	c
1910	–	–	1930	–	–	1950	c	–
11	–	–	31	c	c	51	–	–
12	c	–	32	–	–	52	c	c
13	c	c	33	–	–	53	–	–
14	c	c	34	–	–	54	–	–
15	–	–	35	–	c	55	c	–
16	–	–	36	–	c	56	–	–
17	c	–	37	c	–	57	–	c
18	c	–	38	c	–	58	c	c
19	c	c	39	c	c	59	–	c

changes here with those observed in western Europe over the same period.

In this part of the Old World, interest in the immigration of butterflies from the south has been high for many years. In Britain we have annual reports on migrant insects, including the Painted Lady, for over thirty years; in Holland, since 1940, in Ireland since 1950, and in Austria since 1956. Also a study of earlier records, from 1850 to 1930, from old natural history books and journals in Britain, was published by Cockbill in 1942 (Williams et al., 1942). The information available for the years 1900–1959 for years of unusual abundance in Britain has been added to the North American records in Table 1. From this double set of data Table 2 has been made, showing in how many years, out of the total of sixty, the Painted Lady has been common in both continents (A); in how many years rare in both continents (D), and how often common in one and rare in the other (B and C).

It is possible to calculate from the total number of "rare" and "common" years in each continent, how many of the sixty years should be in each of the four classes, *on the assumption of no relation whatever between the two.* These numbers are shown in brackets in Table 2.



Figs. 5 and 6. The known distribution of immigrant Painted Lady butterflies in North America in the years 1951 and 1952. The former, a year of almost complete rarity or absence, the latter, a year of widespread immigration.

TABLE 2. AN ANALYSIS OF THE RECORDS IN TABLE 1 TO SHOW THE NUMBER OF YEARS, OUT OF 60, IN WHICH THE PAINTED LADY WAS: (A) UNUSUALLY COMMON IN NORTH AMERICA AND IN BRITAIN; (B) COMMON IN NORTH AMERICA BUT NOT IN BRITAIN; (C) COMMON IN BRITAIN BUT NOT IN N. AMERICA; AND (D) RARE IN BOTH AREAS. THE NUMBERS IN BRACKETS ARE THE NUMBER OF YEARS EXPECTED IN EACH CLASS IF THERE WERE NO ASSOCIATION BETWEEN THE TWO AREAS

		IN BRITAIN		
		common	rare	total
IN NORTH AMERICA	common	A. 18 (15.4)	B. 6 (9.6)	24
	rare	C. 18 (21.6)	D. 18 (15.4)	36
	total	36	24	60 years

It will be seen that in the classes of "simultaneous abundance" the observed number of years are both greater than that calculated on the assumption of no relation, but in the two classes of "common in one continent and not in the other", the observed numbers are below the calculated.

A statistical calculation (using Yate's correction for small numbers) gives the parameter χ^2 as 2.78, which, from 60 observations and one degree of freedom, indicates a probability of 0.10 that the result obtained could be due to chance. Otherwise the chances are 9–1 the result has some significant cause. This is not *proof* of a relation, but suggests a possibility worth further investigation. It is however interesting to note that Grant (1937) has already shown a similar relation between high levels of

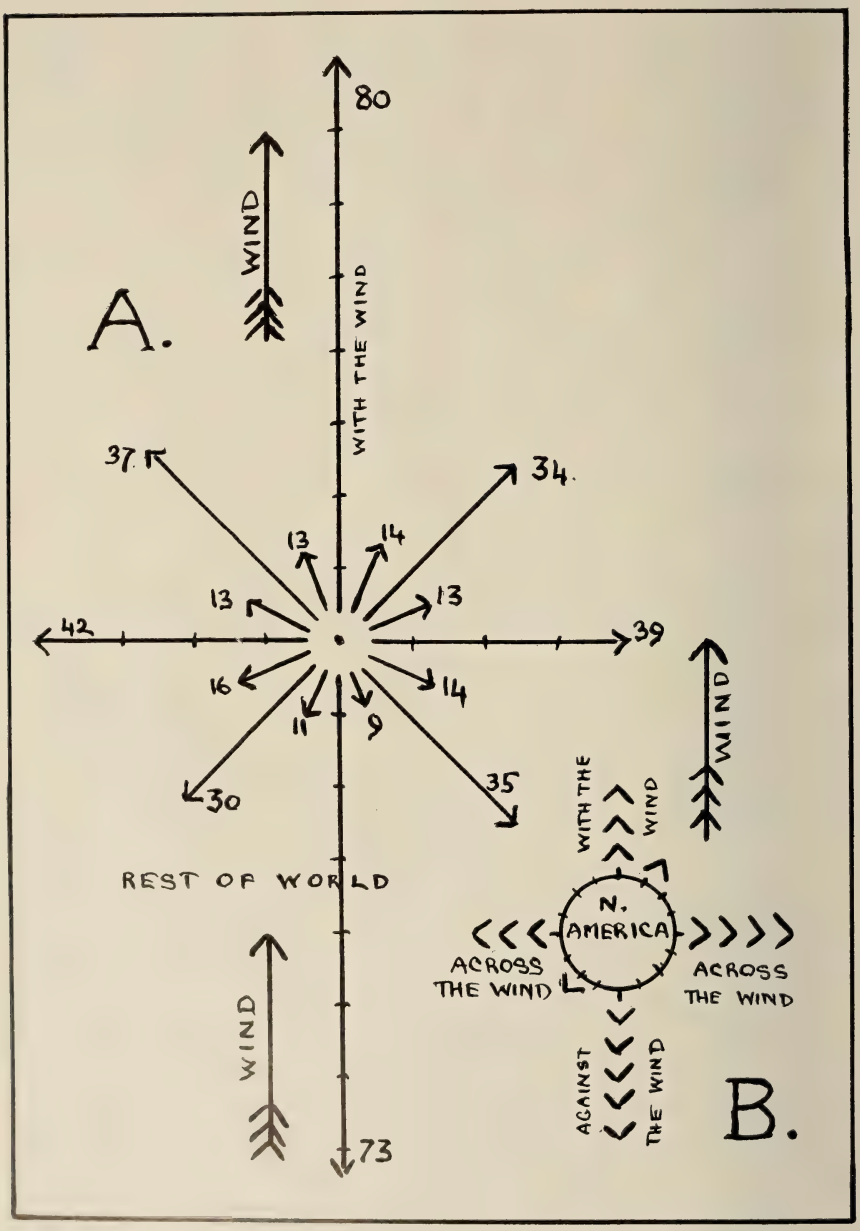


Fig. 7. (A) Nearly 400 observed flights of the Painted Lady butterfly, from all parts of the world, in which both flight direction and wind direction were recorded, arranged according to the angle between the flight direction and the wind. (B) Seventeen records from North America arranged on the same plan.

immigration of the hawk-moth *Celerio lineata* Fabr. in North America and its subspecies *C. l. livornica* Esp. in Europe.

Since the idea of common origin for the two continents can be ruled out, it seems likely that there is some common factor, presumably meteorological, which bring about the unusual abundances, either in Europe or in North America, or more probably in the sources of the immigrants in North Africa or in Mexico. If this is so, such specially favourable conditions cannot be local events, but must include causes which are linked together from North Africa (10° W to 30° E) to Mexico (100°–120° W longitude), a distance of nearly one third of the earth's circumference.

The Problems of Orientation and Wind

There is no doubt that in North America, as also in Europe and North Africa, there are very regular movements of insects which are different in direction at different seasons of the year. They normally have a northerly component in the spring and early summer and a southerly component in the fall.

The mechanism of this orientation is still uncertain. It has been attributed to the direction of the sun's rays (polarised or unpolarised), or to the earth's magnetic field; but most often to the direction of the wind. The main wind-orientation theories are first that the insects are helplessly blown by the winds and take no part themselves in determining the general direction of movement of the population. The second suggestion is that the insects are able to appreciate the direction of the wind while they are flying, and can either fly at a constant angle to it or can straighten out their flight in the direction in which they "want" to go, by allowing for the drift.

It is of course obvious that when an insect is flying in an air current of greater velocity than its own maximum speed, the insect *must* drift downwind. The smaller it is, the more likely it is to drift. The main aerial movements of insects like Aphidae and small Diptera must be generally downwind. But the more powerful fliers such as the larger butterflies and moths can fly steadily against moderate winds, and the butterflies usually shelter during periods of strong wind. The locusts are an exception as, although they have an air speed of about ten miles per hour, the swarms often rise to several thousand feet, where the wind speed is greater than this. As a result these high-flying swarms tend to move down-wind.

I have seen Painted Lady butterflies in Egypt flying, against a light wind, at a ground speed of about 12 miles per hour; and other observers have given ground speeds of 15 to 18 miles per hour (the latter also against a light wind). In California McGregor has also estimated a speed

of about 12 miles per hour, so that provided that they fly near the ground, they can make headway, except in high winds, when they tend to settle.

The little evidence we have for North America about the relation of flight to wind direction is shown in Fig. 7B, in which all the available records are shown; the wind is assumed to be blowing from the bottom of the diagram. The number of records is small, but they show almost equal numbers of flights with the wind, against it and across to left or to right. This evidence is very strongly upheld by a large number of records of flight direction and wind in *V. cardui* in other parts of the world, which are summarised in Fig. 7A. There are 473 observations by many different observers in many different countries and they give no support to the idea that there is within sight of the ground, any constant relation between wind direction and flight. The slight excess of flight records with or against the wind is probably a biassed observational error, as observers are more likely to take notice of cases where the wind is with the flight ("obviously the cause"), or against it ("how curious"), than merely across.

Association of Species in a Migratory Flight

A remarkable feature of the northward spring migration of the Painted Lady into Europe is its frequent association with two other species of Lepidoptera, a noctuid moth *Plusia gamma* Linn., known popularly as the "Silver-Y", and a pyralid *Nomophila noctuella* Schiff. Many records exist over the last hundred years of the simultaneous appearance in numbers of all these species. It has been noted at sea in the middle of the Mediterranean, on the south coast of France, in the British Isles and elsewhere. In Yugoslavia, where the caterpillars of the Painted Lady destroy soya-beans and other crops, the association is regular that it has been suggested that the use of light traps to attract *P. gamma* might give an early warning of possible immigrations of the butterfly.

The pyralid known as *N. noctuella* is widespread in N. America, and for many years it was thought that *Plusia gamma* also occurred, but the North American species has been separated off under the name of *pseudogamma*. Little appears to be known of its migratory habits.

In all the available history of outbreaks of *V. cardui* in America I have found only one reference to a similar association, when damage by caterpillars of *V. cardui* and *Plusia ni* Hubn. occurred simultaneously in Utah in 1965. This species (related to *P. gamma*) is known as a rare immigrant into Britain.

Close observations are needed to see if any association of species occurs in North America similar to those in Europe.

1958	APRIL 1ST	PALM SPRINGS ARIZONA	TO S.E
Year	Month and Dates	Locality	Flight direction if definite
	LIGHT N.W.	"PHENOMENAL" AT 11 A.M. 16 P.MIN ON 15 YARD FRONT	NOT STATED
Time of day	Wind direction and force	Numbers seen	No. Captured ; in whose collection
		FLIGHT THINNED OUT ABOUT 8 MILES TO WEST	
Sex	Condition (fresh : worn)	Notes :—Extent of flight ; speed ; pairing : egg-laying ; etc.	
NEXT TWO DAYS COLD, WET, WINDY NONE SEEN SINCE			4-7 FT
Present and past weather conditions ; temperature, rain, sun, cloud, thunder, barometer, etc.			Height above ground
RALPH DAWSON 14 DESERT LANE. R2 MESA ARIZONA			LETTER OF 20. MAY. '58
Observer and Recorder (names and addresses)			Source of information ; reference
V. CARDUI	NONE MENTIONED		R.D.
Name of species	Other species in flight		Identified by

Fig. 8. The standard record card used in Britain for filing information of migrant insects, filled in from a letter describing a migration of Painted Ladies in Arizona in 1958.

Discussion

My object in writing this brief account of the status of *Vanessa cardui* in North America is three-fold: firstly, to summarise our knowledge and ignorance of the facts, and to emphasise what seems to be their basic pattern; secondly, to get more information on the history and past outbreaks to check our conclusion; and thirdly, to get fuller information about immigrations in the future.

The first of these requires little comment.

For the second, there must be lying about in note books, files, collections, museums, in obscure journals and in memories, much information about the occurrence of the Painted Lady in past years, and in different parts of the continent. Every record which includes at a minimum the year and the locality, with some idea of the numbers, is a new piece to fit into the jig-saw picture.

For observations in the future, we can only hope that if entomologists are prepared in advance they may be able to observe new details, when they are fortunate enough to witness an actual migration, or even merely the presence or absence of the butterfly. For many years in Britain we have been using a standard record card for summarising information. Fig. 8 shows one of these on which is extracted information of a migration of

V. cardui in Arizona. The different sections on the card give some idea of the points that should be noted and recorded. It is unlikely that all can be filled in, but as many as possible should be attempted, and particularly the direction of flight and of the wind (with any variations during the observations). If specimens can be captured, dissections of the female to see if fat body or developed ovaries are dormant, can give important information on probable previous or later activity.

The field study of insect migration is a science in which little can be planned in advance: also observations can seldom be repeated. The observer must be ready to take advantage of the opportunity of the moment, and all students must depend on the experience of others as well as their own.

"By mutual confidence and mutual aid
Great deeds are done, and great discoveries made."

Please make sure that your observations as well as your conclusions are made available for others.

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VARIATION OF *GRAPHIUM MARCELLUS* IN MISSISSIPPI (PAPILIONIDAE)[1]

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Introduction

Graphium marcellus (Cramer) was reported from Mississippi (Mather and Mather, 1958) as "apparently generally distributed and locally rather abundant; February through August. The spring form, with shorter tails, is found from February through April; the summer form, with longer tails, May through August. The earliest record . . . is . . . Ballground, Warren Co. on 9 February 1957." A group of 67 Mississippi specimens (48 ♂♂, 19 ♀♀) taken on dates from 9 February to 27 August, between 1951 and 1967, at 20 localities in 12 counties is now at hand and has been examined. The 12 counties include three in the northern part of the state (Chickasaw, Tishomingo, and Tunica), five in the central (Claiborne, Copiah, Hinds, Rankin, and Warren), and four in the southern part (Forrest, Harrison, Jackson, and Pearl River). A September record: 24 Sept. 1966, Tupelo, Lee Co., John Bryson, was provided by Charles Bryson; I have not seen this specimen. The sample of 67 specimens was arranged by date of capture and data were recorded for sex, forewing length, tail length, tail pattern, and other parameters. The results are presented and discussed as they relate to seasonal and other kinds of variation, nomenclature, and distribution.

Characters

Sex: The literature on *G. marcellus* contains few references to characters that might conveniently be used to separate specimens by sex. Clark (1935), in describing the kite swallowtails, stated "the abdominal margin of the hind wings is broadened in the males, and usually bears a distinct scent organ." Field (1940) wrote of this group "the inner margins of the hindwing . . . are turned upward and rolled over, forming pockets that contain androconia." Inspection of the inner margins of the hind wings of the Mississippi specimens revealed differences that appeared to be consistent and the series was sorted by sex on the basis of these differences. The specimens were subsequently examined by Dr. John M. Burns on 19

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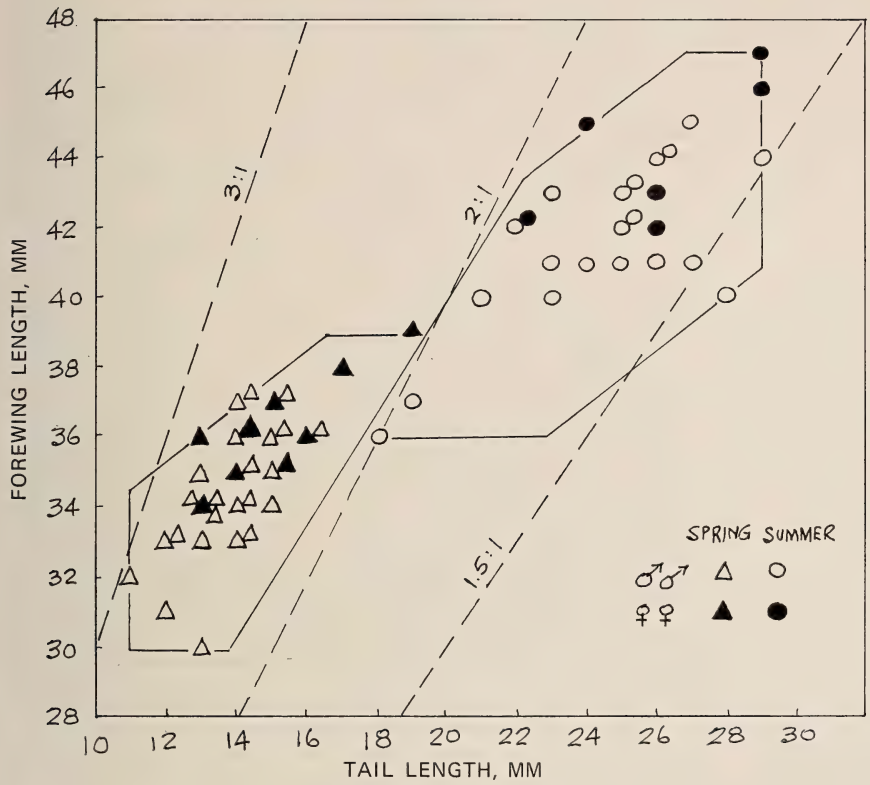


Fig. 1. Relation of forewing length to tail length for 59 specimens of *G. marcellus* from Mississippi, showing division of the group into spring and summer subgroups and boundaries of available data.

August 1967 and I was pleased to find that my sorting of this series by sex was confirmed by him in each case. I suggest that future writers note this diagnostic criterion for the guidance of others.

Dimensions: Each specimen on which such measurements could be made (eight of the specimens had neither tail complete) was measured to the nearest millimeter for forewing length and tail length. The range in forewing lengths of the 67 specimens is from 30 to 47 mm. The range in tail lengths of the 59 specimens is from 11 to 29 mm. The forewing and tail lengths are plotted in Fig. 1. On Fig. 1 are also shown lines of loci of forewing length to tail length ratio of 1.5:1, 2:1, and 3:1. Since the forewing length : tail length ratio changes with change in forewing length and tail length, the ratio was calculated for each specimen. The

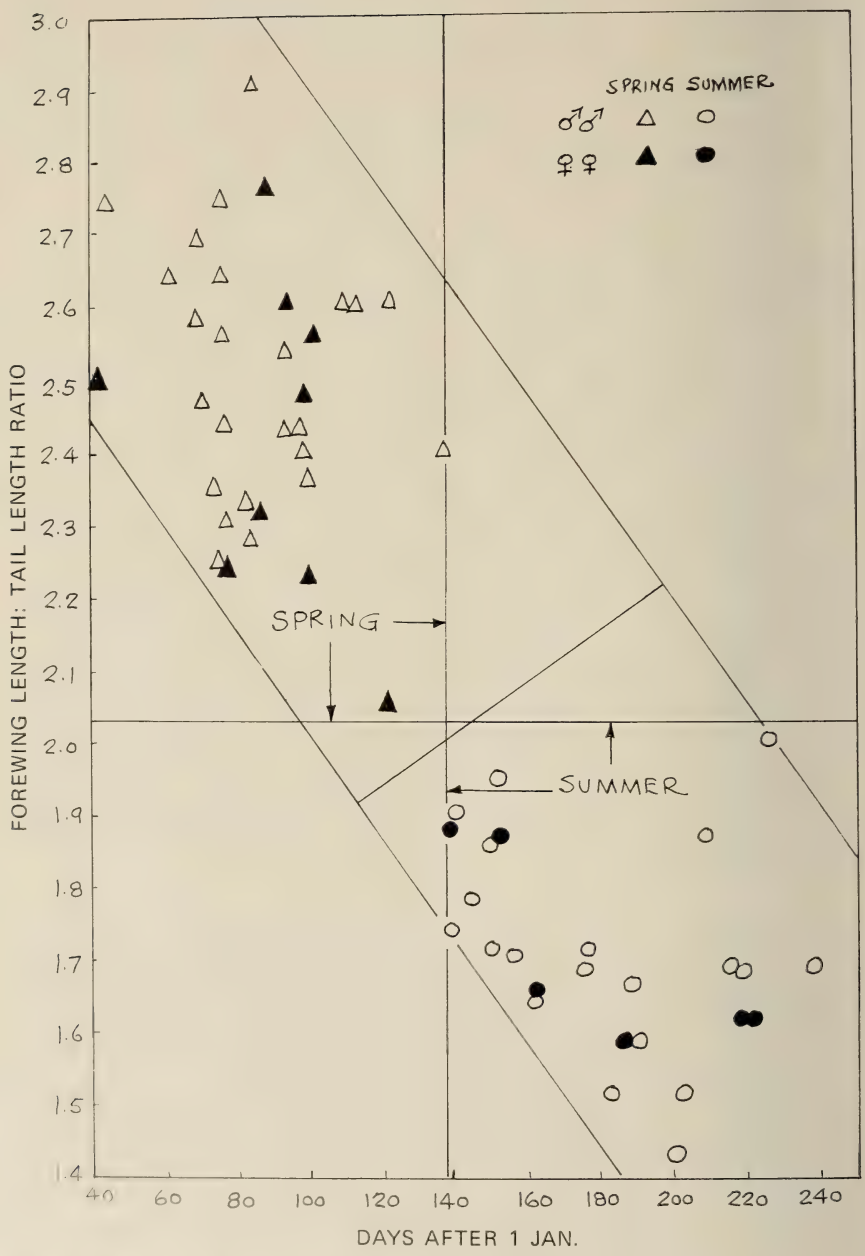


Fig. 2. Relation of forewing length : tail length ratio to date of capture for 59 specimens of *C. marcellus* from Mississippi, showing separation into spring and summer [illegible] FWL : TL = 2.05 and 137 days after January (17 May).

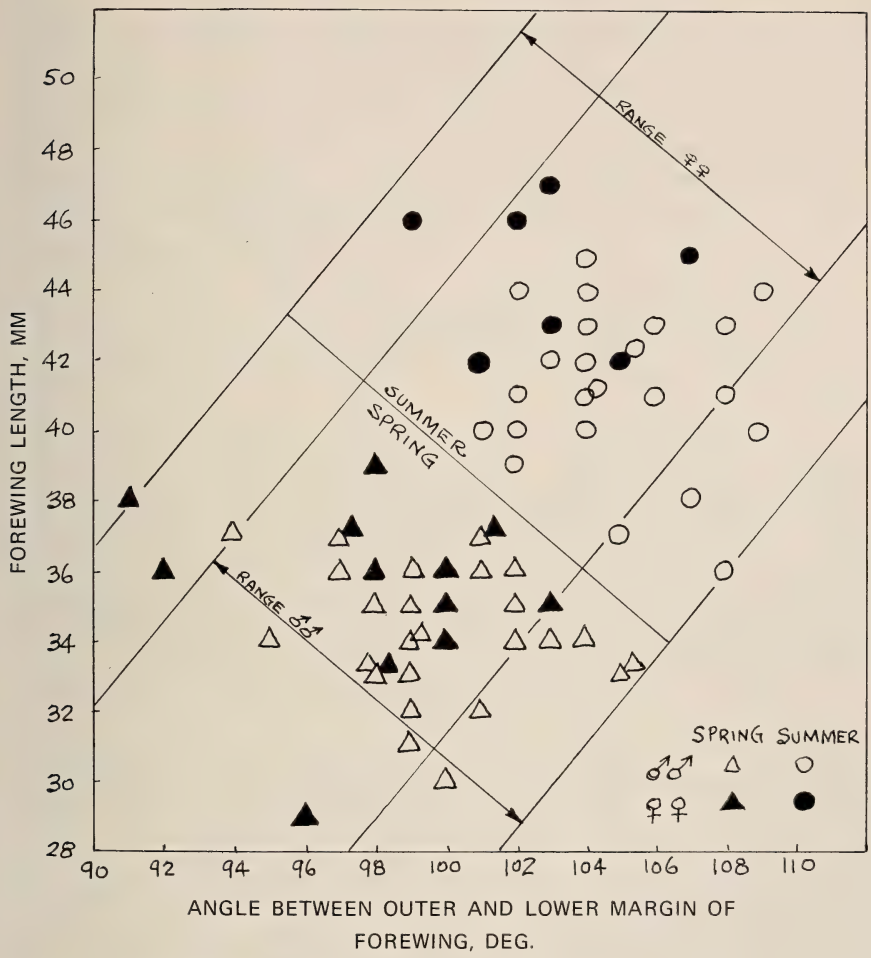


Fig. 3. Relation of forewing length to angle between outer and lower margin of forewing for 67 specimens of *G. marcellus* from Mississippi, showing separation into spring and summer subgroups.

range for the 59 specimens was 1.43 to 2.91. These results are plotted in Fig. 2 against dates of capture.

Tail Pattern: Two types of tail pattern were recognized: (a) only the tip of the tail white; (b) white extending far up each side of the tail above.

Red Spot or Spots at Anal Angle of Hind Wing: Four variations of this character were recognized : (a) red spot wide, covering the space between three veins, and step-shaped; (b) red spot of same dimensions as

in (a) but divided by a narrow vertical black line along the intermediate vein into two red areas each essentially square; (c) red spot reduced so as to occupy the space between only two veins, and rounded; and (d) red spot similar to (c) but accompanied by a much smaller satellite spot in the adjacent space.

Submarginal White Lunules on Hind Wing: The number of prominent white submarginal lunules was found to range from two to four. When only two or three were prominent, often one or two were faintly indicated.

Fifth Black Stripe on Forewing: The middle, fifth, black stripe on the forewing above extends downward only through the cell. Three forms of this stripe were noted: (a) a band of generally uniform width, (b) a band narrowing sharply away from the costal margin, and (c) the band reduced to a spot.

Angle between Outer and Lower Margins of Forewing: The angle between the outer and lower (inner) margins of the forewing was measured for each specimen. The measurements were made using a contact goniometer.[3] The relation between these results and forewing length is plotted in Fig. 3.

Curvature of Outer Margin of Forewing: The outer margin of the right forewing was inspected from above and classified as "concave" or "convex".

Discussion

Variation: A principal type of variation in *G. marcellus* is seasonal. Brown (1965) quoted Boisduval's letter of 1 June 1873 to W. H. Edwards in which he wrote: "I believe you are right to put together *Ajax* and *Marcellus* in spite of the difference there is in the coloration of the larvae and the length of the tail of the insects in the perfect state [imago]. In spite of the opposite opinion of Abbot, they are probably only seasonal variations." The data on the Mississippi sample were therefore arranged chronologically by date of capture and were examined together with the relationships plotted in Fig. 1, 2, and 3 to determine if seasonal subgroups could be segregated, and if so, how many such subgroups appeared to be clearly differentiable and where the subgroup boundary or boundaries should be drawn both with regard to characters and time. This examination led to the conclusion that the population represented by this sample lent itself better to the drawing of one rather than more than one boundary and hence was more clearly separable into two rather than to more than two seasonal forms. The boundary that appeared most reasonable to draw on the basis of change in characters corresponds, on the time scale, to the

[3] Model B, designed by S. L. Penfield, patented 31 July 1900, New Haven, Conn.

date of 17 May; one of three specimens taken on that date being assignable by characters to the earlier "spring" group; the other two being assignable to the later "summer" group. The final versions of Fig. 1, 2, and 3 were then modified using different symbols for specimens assigned to the two groups. In each case a line can be drawn between areas in which all the points representing specimens belonging to the two groups fall.

The two seasonal forms as segregated from the present sample may be characterized and compared as follows:

	Earlier "Spring"	Later "Summer"
Dates taken	9 Feb–17 May	17 May–27 Aug
Forewing length, mm (FWL)	29–39	36–47
Tail length, mm (TL)	11–19	18–29
FWL/TL	2.05–2.91	1.43–2.00
Tail pattern	White at tip only (5 exceptions)	White extending up sides
Red spots on hind wing	Broad	Narrow (1 exception)
HW submarginal lunules	3 + to 4	Five have fewer than 3 +
FW margin angle, deg.	102 or less (5 exceptions)	102 or more (3 exceptions)
Number of specimens	37 (25 ♂♂, 12 ♀♀)	30 (23 ♂♂, 7 ♀♀)

From the forewing characterization and comparison it is concluded that the most unambiguously diagnostic characteristic is forewing length : tail length ratio. Since the tail length increases with time more rapidly than does the forewing length and since absolute dimensions are influenced at any point in time by non-dependent factors such as sex and food, it is not surprising that this ratio appears best to indicate the time-dependent change that is observed. If this ratio is 2.00 or less the specimen belongs to the later form regardless of its absolute size or other features. The second most unambiguous character is the width of the red spot or spots in the anal angle of the hind wing. If this area is broad, occupying the spaces between three veins, the specimen belongs to the earlier form with only rare exceptions (one in this series). All specimens having white on the tail confined to the tip belong to the earlier form but, in this series, five having white extending up the sides of the tail are also assigned to this group. Since the sample includes comparable numbers of individuals representing the two forms and since it includes individuals taken over a period of 17 years, I believe it is as representative of the population sampled as one of this size could be.

The nature of the curvature of the outer margin of the forewing does not appear to be time dependent. It appears rather to be associated with the sex of the specimen, as might be expected by analogy with other species, but there are a significant number of exceptions to the association as is shown in the following tabulation:

Curvature of outer margin of right forewing, viewed from above	Number of specimens ♂♂	♀♀
concave	44	8
convex	4	11

Variation in the shape of the fifth black stripe on the forewing above, from a band of nearly uniform width to a band that narrows sharply downward, appears to be random and not time dependent. The more extreme reduction of this band to a spot was observed in four specimens, all belonging to the later form (3 ♂♂, 1 ♀) and, in a manner similar to the tendency to obsolescence of some of the submarginal lunules on the hind wing above, appears to be a character that is more likely to occur among individuals of that form but cannot be described as diagnostic of that form.

Nomenclature: Having discussed the results of the study of variation within the sample of the Mississippi population it now seems appropriate to discuss the names that have been used and the variation that has been reported for populations of *G. marcellus* both throughout its range and in specific portions of its range. Dos Passos (1964) gave the nomenclature as follows:

"*Graphium*
269. *marcellus* (Cramer), "1779" [1777] (gen. vern.)
‡ ajax (Linnaeus), 1758 (partim) (Opinion 286)
walshii (Edwards), 1872
carolinianus (Holland), 1931 (Opinion 259)
form telamonides (Felder & Felder), "1864–67" [1864]
form floridensis (Holland), 1898
gen. aest. lecontei (Rothschild & Jordan), 1906"

and then records the names given to four aberrations.

Holland (1931, Plate XLIV) figured four specimens: 1, spring form *carolinianus* Edwards, = *marcellus* Cramer; 2. spring form *floridensis* Holland (type); 3. summer form *telamonides* Felders, = *lecontei* Rothschild & Jordan; and 4. spring form *walshii* Edwards (type). The form represented as # 4 "walshii" by Holland is similar to that which appears earlier in Mississippi; the form represented as # 2 "floridensis" by Holland which is quite similar to # 4, is matched by a few Mississippi specimens

but is not differentiable as a seasonal form in the present sample. The form represented as # 1 "carolinianus" by Holland is typical of a very few intermediate specimens from Mississippi that are rather inconsistent in their characters. The form figured as # 3 "telamonides" by Holland is similar to the later, "summer" form as characterized above for the Mississippi series.

Most previous workers have discussed seasonal forms of *G. marcellus* in terms of three such forms: smallest = earliest, intermediate both in time and characters, and largest = latest. Clark (1932) wrote of the population of the District of Columbia and vicinity as forms "marcellus," "telamonides," and "lecontei" having forewing lengths of 33–37 mm, usually 35 mm for "marcellus," and 39–48 mm for "lecontei." Field (1940) used the same form names for Kansas and stated that the forewing of "marcellus" ranged from 32–36 mm, averaged 34 mm, and the tails were 15 mm or less; "telamonides" had forewings averaging 37 mm; and "lecontei" (in Douglas Co.) averaged 44 mm forewings and 23 mm or longer tails. Clark & Clark (1951) wrote of the Virginia population that early spring individuals had forewings usually 32–35 mm but up to 40 mm on the outer Coastal Plain. They did not use form names for the earliest and latest forms but referred to the late-spring form as "telamonides." They also discussed the finding of some individuals that closely resembled "the southeastern spring form *floridensis*." They stated that the summer form in Virginia had forewings about 45 mm long. In no case has a report been found indicating the size of the sample upon which the observations as to average or range in size was based. All writers agree that as the season advances the butterflies get larger and their tails get longer. No reference was found to the use of forewing length : tail length ratio as a parameter. Kimball (1965) wrote that the Florida population was "abundant throughout the state from March to December. Morgan wrote '. . . of the three subspecies (sic) described as differing slightly in size, hairiness, color, pattern, and length of tails, and supposed to be restricted to certain seasons or regions, all may be matched by Hillsborough County specimens throughout the year.' Fuller states that around Cassadega the species occurs in the three forms in their usually recognized sequence; *marcellus*, February; *walshi* (sic) (Edwards), March, and *lecontei* (R. & J.), June and July." Kimball concluded: ". . . . the whole subject of subspeciation in *marcellus* needs to be worked out." Forbes (1960), referring to New York and neighboring states, mentioned an "early spring form (*marcellus*)" and a "summer brood (*lecontei*)" adding "intermediate late spring specimens are *telamonides* Felder" having some characteristics like the earlier and some like the later forms. Haydon (1933) stated that, in Maryland, there were "three dis-

tinct seasonal forms": *marcellus* 2.50–2.75 in., *telamonides* 2.75–3 in., and *lecontei* 3–3.25 in. Weed (1926), likewise referred to "three distinct forms": *marcellus*, small early spring with short tails that show white only on the tips; *telamonides*, late spring, larger, tails a little longer, and with more white on outer half; and *ajax*, summer, larger, with very long tails. Comstock and Comstock (1940) wrote of "three distinct forms," early spring (*marcellus*) 2.6–2.8 in., tails 0.6 in., tipped with white = *walshii* Edwards; late spring (*telamonides*), a little larger, tails ⅓ longer, bordered by white on distal ½ to ⅔ of length; summer (*ajax*) 3.2–3.5 in., tails ⅔ longer than early spring.

Although, as has been noted above, most previous workers have discussed seasonal variation in terms of three "distinct" forms, no illustration designated as representing the intermediate form was found in the literature. The intermediate form has usually been called "telamonides" but the only figure designated "telamonides" that I found was that given by Holland (1931) who refers to it as "summer form = *lecontei*." A total of eleven figures were found. The references to these figures, the measured forewing and tail lengths and the computed forewing length : tail length ratio are tabulated below:

Reference	FWL, mm	TL, mm	FWL/ TL	NO. FIG. 4
Holland (1931), plate XLIV, fig. 1 ♂ spring	38	16	2.38	1
fig. 2 ♂ spring "'floridensis"	38	15	2.53	2
fig. 3 ♂ summer "telamonides"	44	24	1.83	3
fig. 4 ♂ spring "walshi"	34	14	2.43	4
Comstock & Comstock (1904), plate V, fig. 1 spring	37	14	2.64	5
fig. 2 summer	41	23	1.78	6
Klots (1951), plate 24, fig. 7 ♂ spring (Pennsylvania)	21(35)[4]	9(15)	2.33	7
fig. 8 ♂ summer (Alabama) "lecontei"	26(43)	17(28)	1.54	8
Howe (1964), plate 9, fig. 4 (summer)	46	24	1.91	9
Clark (1932), plate 48, figs. 1, 2 ♀ summer (Maryland)	45	25	1.80	10
plate 49, figs. 1, 2 ♀ spring (Maryland)	33	14	2.36	11

[4] Values in parentheses are computed with allowance for stated reduction in published size of figure.

The forewing lengths and tail lengths tabulated above are plotted on Fig. 4 which is drawn to the same scale as Fig. 1 and on which are shown the outlines of the limits of the data for the Mississippi sample. There is [illegible] basis for considering the establishment of an intermediate group from

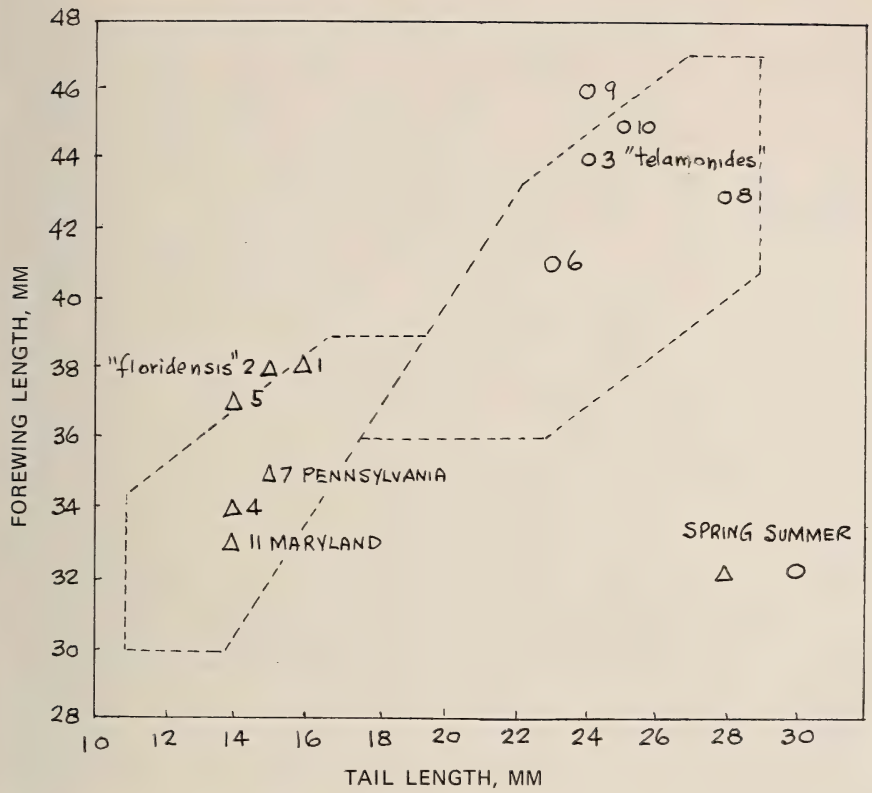


Fig. 4. Relation of forewing length to tail length for 11 specimens of *G. marcellus* figured in the literature and showing the boundaries for these parameters of the available data on the Mississippi population taken from Fig. 1.

these data than from the Mississippi data. The range in FWL/TL ratios for the eleven figured specimens and for the Mississippi sample are compared below:

	Spring	Summer
Figured specimens	1.54–1.91	2.33–2.64
Mississippi sample	1.43–2.00	2.05–2.91

Distribution: Ehrlich & Ehrlich [1961] gave the range of *G. marcellus* as "Florida to Texas, northward to Canada (rare in northern part of range)." Macy & Shepard (1941) gave it as "from southern New England through most of the United States east of the Rocky Mountains. . . . reported several times from southern Michigan north to Saginaw Bay . . ." Macy (in Macy and Shepard, 1941) reported seeing one in Hennepin Co.,

Minn. on 3 July 1932 and recorded Franzen's report of one having been taken in downtown Minneapolis. Sorenson (1967) states that only a single specimen is known from Minnesota, from Mankato, Brown Co. It was not listed for Colorado by Brown, Eff, and Rotger (1957). Forbes (1960) gave the range as "Conn. to Ill., and s to Fla." Fiske (1901) stated that it was "said to have been taken in Hooksett (New Hampshire) but I have nothing more than mere hearsay to go by." Shapiro (1966) reported taking 46 in the Delaware valley in 10 years. Klots (1951) gave the range as southern New England (rare) west through southern Ontario, Mich., Minn., and Wisc., south through Central Florida and Gulf States. Field (1940) wrote: "Canada south to Florida and west through the eastern half of Kansas, Oklahoma, and Texas." He gave records from eight Kansas counties. Riotte (1967) noted that a specimen had been taken at Humber Plains west of Toronto in 1891 but not since. Masters (1967) listed it as abundant to common in northeastern Arkansas. Kendall (1964) reported it as found from late March to early July in east Texas. He collected eggs, larvae, and foodplant (*Asimina parviflora* (Michaux.) in Polk Co., Texas, on 14 April 1962, and reared nine adults that emerged on 18–19 May, 6 June, 31 Aug 1962, and 25, 27 March and 11 April 1963. It was not listed for the Waco, Texas, area by Gooch & Strecker (1924). Lambremont (1954) and Ross & Lambremont (1963) recorded its occurrence in seven Louisiana Parishes; Kendall (1964a) added an eighth; the flight period in Louisiana, based on these reports, is 17 March to 10 September. Harris (1950) reported it abundant over the entire state of Georgia, February to October.

After reviewing these somewhat differing statements, I have concluded that the available data indicates that *G. marcellus* occurs throughout Florida (Kimball, 1965) rather than only to central Florida (Klots, 1951) and generally in an area bounded by the Atlantic Coast northward at least to Connecticut (Forbes, 1960) and westward, possibly into New Hampshire (Fiske, 1901), through Toronto, Ontario (Riotte, 1967), Michigan (Macy & Shepard, 1941), and Minnesota (Sorenson, 1967); southward to include the eastern halves of Kansas and Oklahoma (Field, 1940) and east Texas (Field, 1940, Kendall, 1964).

Summary

A sample of the *Graphium marcellus* (Cramer) population of Mississippi, consisting of 67 specimens (48 ♂♂, 19 ♀♀) taken on dates between 9 February and 27 August between 1951 and 1966 at localities in 12 counties, distributed over the state, was examined. Data were obtained on forewing length, tail length, forewing length : tail length ratio, distribution

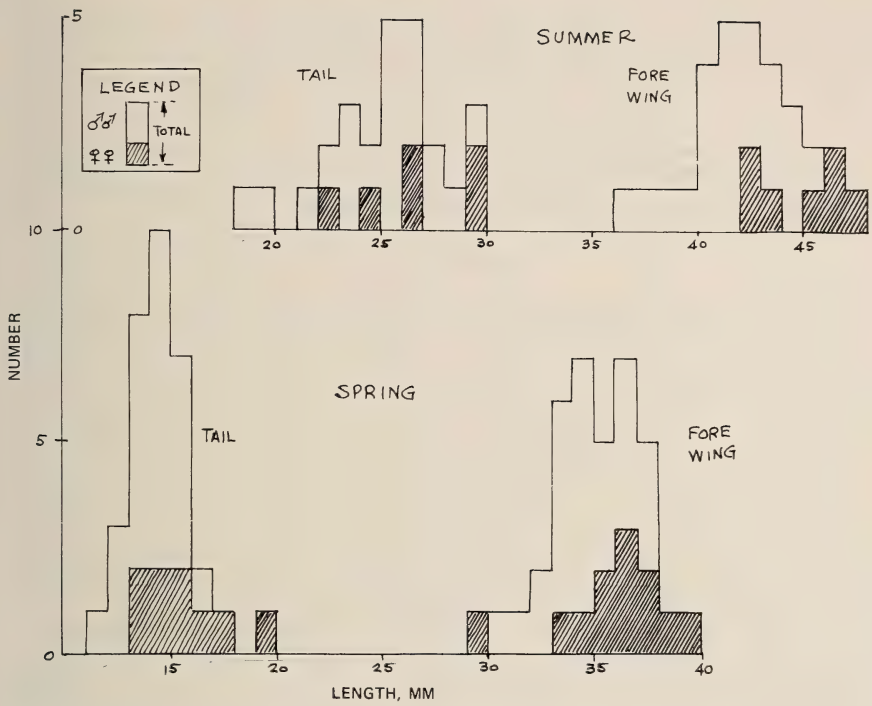


Fig 5. Distribution of forewing lengths and tail lengths of Mississippi *G. marcellus*, divided into spring and summer subgroups.

of white at tail tip, variation of red spot or spots at the anal angle of hind wing, angle between outer and lower margin of forewing, curvature of outer margin of forewing, variation in submarginal lunules of hind wing, and variation of form of fifth black stripe of forewing. It was concluded that the major variation is time dependent, that the sample may most logically be considered as including representatives of two (rather than more than two) seasonal forms, that the most unambiguous character for separating these forms is forewing length: tail length ratio; that the change from the earlier form to the later form occurs when this ratio drops to 2.00 or less which corresponds in time to approximately 17 May. Concurrently, but less unambiguously, the forewing length increases from 37 mm or less to 38 mm or more, the tail length from 18 mm or less to 19 mm or more, the white at the tail tip extends up the sides of the tail, the red spot at the anal angle of the hind wing narrows from being two spaces wide to being one space wide, and the angle betwen the outer and lower margin of the forewing increases from less than 102° to more than 102°. These two forms may be referred to as earlier and later, or "spring" and "summer," or

as *gen. vern.* "marcellus" and *gen. aest.* "lecontei." A character that may conveniently be used in sexing specimens is described. Conflicting statements about geographic range are reviewed. It is concluded that *G. marcellus* occurs throughout Florida and generally northward at least into Connecticut, possibly into New Hampshire, westward to Toronto, Ontario, Michigan, and Minnesota; southward to include the eastern halves of Kansas and Oklahoma, and into eastern Texas.

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THE AEGERIID *RAMOSIA FRAGARIAE* IN A FLIGHT TRAP, AND THE INTERPRETATION THEREOF

In mid-August 1966, my wife and I were camped at Poker Flat, an attractive small meadow at 5040 feet altitude in the forested Siskiyou Mountains of the northwest corner of Siskiyou County, California. On the thirteenth I foolishly kept my eye on a butterfly instead of on the ground, and ran over a small rock cliff. Fortunately I netted the brute, *Parnassius phoebus sternitzkyi* McDunnough, on the way down, but in landing head first on the talus lost considerable skin from arms, legs and side, and sprained an ankle. Next day I was glad just to sit around camp.

Luckily a flight trap, the simple, one-pole, P. H. Arnaud-adaptation of a Malaise trap, had been put up earlier. It was set on dry, rocky ground between the forest and the marshy southern edge of the meadow, directly above the headwaters of the West Branch of Indian Creek. To be doing something, I hobbled out to empty it every hour. It caught quantities of flies and wasps throughout the day, but at the 3 PM servicing, it contained also a series of a small black and orange clearwing moth, *Ramosia fragariae* (Hy. Edwards). None was caught before or after the 2 to 3 PM period.

I interpreted this as a surprisingly restricted flight period for the species, and later so reported it to several lepidopterist friends (I am a coleopterist). But when the specimens were readied for pinning and spreading a couple of years later, it was seen that there were twelve males and one female, so it is more likely that the female inadvertently flew into the trap and was followed by her hopeful suitors.

This swarming of a number of males around one female may be characteristic of these small clearwings. In my field notes for 26 July, 1964, referring to a spot near Route 14, altitude 8,825 feet, 1.5 miles northeast of the summit of Granite Pass in the Big Horn mountains of north central Wyoming, I recorded: "Near camp found a spot where ♂ ♂ aegeriids were swarming, wasp-like, over a tuft of grass; took a series, then found a live ♀ in [the tuft of] grass; ants were attacking the ♀. Got a couple more ♀ ♀ nearby." These moths proved to be *Ramosia chrysidipennis* (Boisduval).

I am indebted to J. N. Shepard for identifying the butterfly, and to J. W. Tilden for the names of the moths.

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NEW ASPECTS ON THE ASSOCIATION BETWEEN LYCAENID LARVAE (LYCAENIDAE) AND ANTS (FORMICIDAE, HYMENOPTERA)

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Introduction

The association between lycaenid larvae and ants is well known and has been discussed several times in the literature. The most recent survey is by Hinton (1951). Since the majority of published reports are purely descriptive it would seem both desirable and necessary to consider the evolutionary sources of the association using an experimental approach. It is the purpose of this paper to present a summary of the essential facts and new thoughts bearing on this association based on this approach; details of these investigations will be published elsewhere.

Current Hypotheses

The best known hypothesis advanced to explain the relationship between ants and the larvae originated with Thomann (1901). He suggested that ants are able to drive away the caterpillar's parasites, so that the lycaenids benefit from the presence of the ant. In order to attract the ants and keep them in attendance, the caterpillars exude a honey-like liquid from a particular glandular organ, which was first described by Newcomer (1912). According to this hypothesis the association is a symbiosis. This hypothesis, however, has several weak points. Firstly, it has not been confirmed that ants are able to drive away parasitic Ichneumonidae and Tachinidae or even notice their presence. Secondly, there is no evidence that the presence of the ant lowers significantly the rate of parasitism of the caterpillars. Field observations by this writer show that the degree of parasitism of lycaenid larvae fluctuates widely, as is usual in Lepidoptera, whether ants are present or absent. Thirdly, the behavior of ants in respect to lycaenid larvae shows no significant difference between species which lack Newcomer's gland and those which have it.

A second hypothesis has been advanced by Lenz (1917). According to him, the larval adaptations function to prevent aggression by the ant toward the lycaenid larvae, and the honey-like liquid is exuded as a "bribe" to the ants. Recent knowledge supports this hypothesis.

Present Investigations

Methods

According to Thomann's hypothesis the association of ant and lycaenid larvae should lower the rate of parasitism of the larvae in comparison with larvae of the same kinds which are not attended by ants. The examination of this supposition seems to be technically impossible. In field experiments it is not possible to exclude only the ants without changing other factors. Results of experiments under laboratory conditions, on the other hand, do not take into consideration other important field circumstances. It would seem necessary to divide complicated ecological phenomena as far as possible into factors, and to determine whether the presumed connections actually exist.

The behavior of more than 50 ant species in relation to about 35 species of lycaenid larvae has been investigated under both laboratory and field conditions. The anatomy of the larvae has been studied microscopically in the usual manner using serial sections, which were stained with *paf-halmi.* More than 60 species of lycaenid larvae and pupae, mainly European, have been dissected and/or investigated morphologically. Additional ecological investigations have been carried out in the field in order to find out the biotopes and strata inhabited by ants and caterpillars.

The particular behavior of ants and its releasing mechanism

When not excited, ants perform a slow antennal motion which may be called "groping" (Tasten). At excitement, under certain circumstances, their antennal motion becomes much faster and the antennae are bent into an acute angle. This motion may be called "palpation" (Trillern). The antennal positions of both motions are demonstrated in Fig. 1. Ants which are visiting a lycaenid larva perform intensive antennal palpation. This is symptomatic of the fact that the ants perceive the caterpillar as an object distinct from surrounding stones, litter, etc. Therefore palpating may be regarded as a sign for the particular association. The sucking of "honey" which originates from Newcomer's gland, cannot be such a sign because these glands are not present in many species which are attended in the same particular manner by ants. Releasers of groping are a number of common stimuli of less specific significance. Palpating may be released in different ways, but in lycaenid larvae presumably only in chemical ones because no particular mechanical structures could be detected on the integument of the caterpillars where palpation takes place. The ants do not palpate with the same intensity over the whole surface of the caterpillars. They prefer distinct spots whose situation differs according to the species but is constant within it.



Fig. 1. Ants (*Lasius alienus* Foerster) attending a lycaenid larva (*Plebejus argyrognomon* Bgstr.). Notice the antennal positions: groping (extreme left, right above) and palpating (central left).

In the majority of species examined, one of these spots for increased rate of palpation is the dorsal part of the prothorax. Another is situated laterally near the spiracles, principally those near the posterior part of the body (esp. in Lycaeninae and Theclini). A third spot is on the dorsal part of the 7th and 8th abdominal segments surrounding the mouth of Newcomer's gland (esp. in many species of "blues" and Strymonini). These spots contain accumulations of small epidermal glandular organs which may be called "perforated cupolas" (Fig. 2). These organs are, like Newcomer's organ, homologous to hairs. They consist of two cells, one of which is homologous to the trichogen cell of the hair and is sometimes interlaced by longitudinal cavities which enclose the enormous nucleus. It must be supposed that they produce the volatile substance which releases the ant's palpation. The second cell, homologous to the tormogen cell, forms a plasmatic tube which serves as pipe-line for the secretion. The distal part of the organ consists of a cuticular sclerotized perforated plate of about 20 μm in diameter.

The "perforated cupolas" and their secretion, which acts as pheromone, are of major importance for the association between lycaenid larvae and ants. With the single exception of the European *Nemeobius lucina* L., these organs are present in all lycaenid larvae investigated. In some of them (e.g. *Feniseca tarquinius*, *Apodemia mormo*, *Phasis thero*, and *Poecilmitis thysbe*) the perforation of the distal plate can not be recognized distinctly with the equipment used, so that investigation with an electron microscope is necessary. For comparison, caterpillars of several other families have been investigated, but nowhere could perforated cupolas be detected. They are likewise present in the pupae of lycaenids which are attended by ants in the same manner as the larvae.

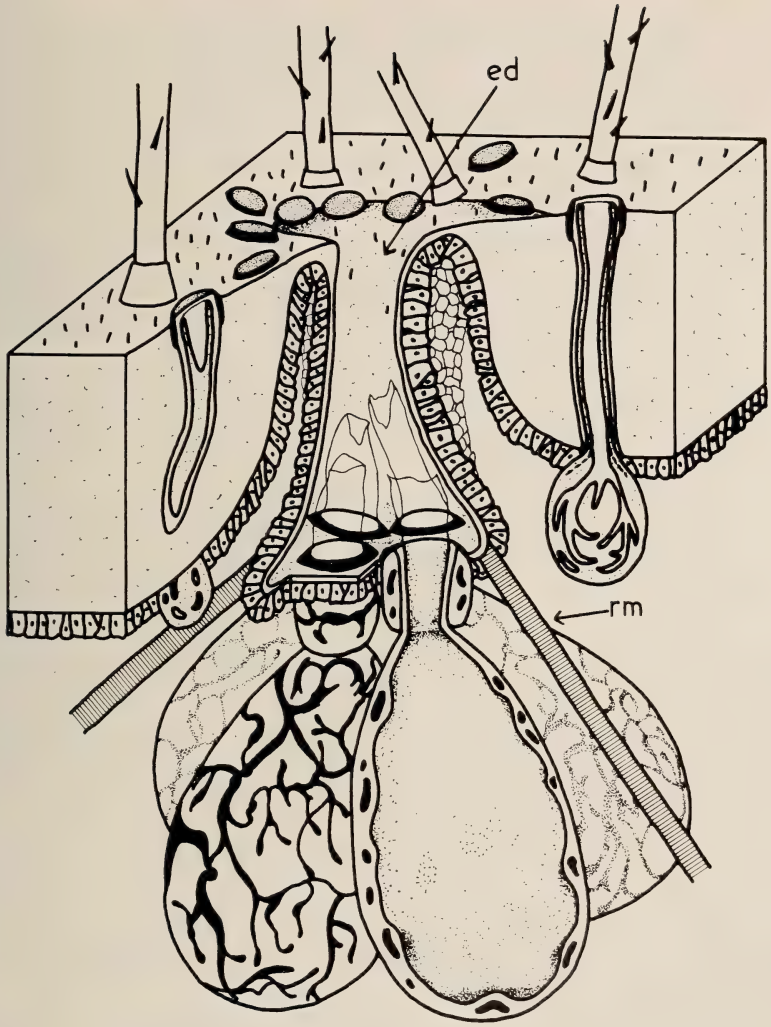


Fig 2. Section of the dorsal part of the 7th abdominal segment of a lycaenid larva, with glandular organs. Center: Newcomer's gland with four glandular bladders, exudation duct (ed) and retractor muscles (rm). Right: "perforated cupolas" section. Above: external parts of several cupolas.

Lack of "beat reflex" in lycaenid larvae

Experiments indicate that when the majority of non-lycaenid lepidopterous larvae are physically disturbed, they perform a reflex lateral beating motion. The biological function of this motion is presumably to shake away rapacious arthropods. Nevertheless, this has little efficiency against

attacks of ants since fast motions usually release aggression in ants. In the lycaenid larvae examined (with the exception of *Nemeobius lucina* and *Phasis thero*) this reflective motion is not performed. This behavior is an additional adaptation to the association with ants.

Interrelations between the construction of integument of the caterpillars and the mandibles of ants

The lycaenid larvae examined have, without exception, soft but tough cuticles of unusually thick dimensions. Caterpillars other than lycaenids of the same size have cuticles about 5–10 μm, but in full grown lycaenid larvae, 200–300 μm thicknesses are usual (Fig. 3). Except for a thin epicuticular layer of less than 1 μm, the integument consists of endocuticle only. The exocuticle is restricted to local sclerotizations, e.g. those in the dorsal part of the prothorax, the head capsule, the thoracic legs, the hooks of abdominal legs and the like.

In behavior experiments, it often happened that ants attacked the lycaenid caterpillars despite the presence of perforated cupolas and Newcomer's glands but, as a rule, the caterpillars were not damaged because of the particular construction of the ant's mandibles. This mandible construction is unique within predacious arthropods. The molar part, a ledge with a row of small teeth, prevents the penetration of the sharp, elongate incisive part through the thick cuticle. Thin cuticles of caterpillars other than Lycaenidae may be easily penetrated. On the other hand, the construction of the mandibles of predacious Carabidae, Staphylinidae, and Silphidae, and the chelicera of spiders, penetrate even this voluminous lycaenid cuticle without difficulty.

The thickness and plasticity of the cuticle is, therefore, a goal adaptation specifically for ants since it does not protect from attacks of other predators. Ant mandibles without this molar ledge also exist (e.g. in Dorylinae and in the social parasites *Polyergus* and *Strongylognathus* etc.), but their owners are not associates of lycaenid larvae.

In addition to its thickness, the lycaenid cuticle is folded in a particular manner, to which fact the larvae owe their woodlice-like appearance. Very vulnerable organs, such as the dorsal blood vessel and ventral nerve cord, are protected under concavities (see Fig. 3). The prominent protrusions contain less important structures such as fat bodies etc. A biting ant is forced to crush one of the prominent cuticular ledges or protrusions between its mandibles, thus giving additional protection to the caterpillar, because its important organs become folded inward and not damaged. It is noteworthy that the size of these ledges corresponds well with the size of the mandibles of medium-sized ants but not with those of other caterpillar predators, which are much larger (Fig. 3).

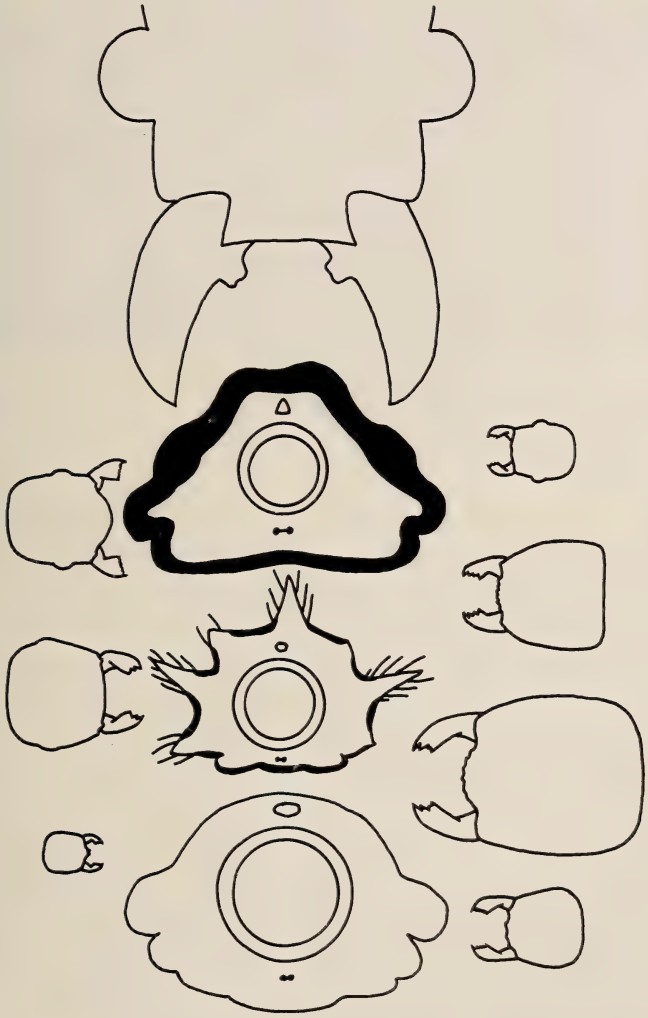


Fig. 3. Cross-section of a lycaenid (above), a nymphalid (center) and a noctuid (below) larva, each with comparative cuticular thickness. Lateral figures are outlines of ant heads. Left from top to bottom: *Myrmica scabrinodis, Cremastogaster scutellaris, Solenopsis fugax.* Right: *Leptothorax lichtensteini, Camponotus ligniperda* (small worker), ditto. (big worker), *Prenolepis nitens.* Above: Outline of the head of a caterpillar-hunting beetle (*Calosoma inquisitor,* Carabidae). Drawn to the same scale.

TABLE 1. Presence of particular organs in lycaenid larvae (only new results, literature records are not included).

Species	Perforated cupolas	Newcomer's gland	Tentacles
Spalginae			
Feniseca tarquinius F.	+	–	–
Aphnaeinae			
Phasis thero L.	+	–	+
Poecilmitis thysbe L.	+	+(?)	+
Theclinae			
Thecla betulae L., *Quercusia quercus* L., *Calycopis beon* Cram.	+	–	–
Strymonidia acaciae F., *Fixsenia pruni* L., *Strymon melinus* Hb.	+	R?	–
Strymonidia spini Den. et Schiff., *S. w-album* Knoch, *S. ilicis* Esp., *Callophrys rubi* L., *C. avis* Chapm., *C. henrici* Grote et Rob., *C. gryneus* Hb., *C. nelsoni* Bdv., *"Thecla" palegon* Stoll	+	+	–
Tomares ballus F., *T. callimachus* Ev., *T. mauretanicus* Lucas	+	+	+
Lycaeninae			
Lycaena phlaeas L., *L. thoe* Guer., + 7 additional European spp.	+	–	–
Zizeeriinae			
Zizina labradus Godt.	+	+	+
Lycaenopsinae			
Lycaenopsis argiolus L.	+	+	+
Everinae			
Everes comyntas Godt., *E. argiades* Pall.	+	+	+
Cupido minimus Fuessly	+	+	–
Lampidinae			
Cosmolyce boeticus L.	+	+	+
Glaucopsychinae			
Scolitantides orion Pall., *Philotes vicrama* Moore, *Glaucopsyche alexis* Poda	+	+	+
Iolana iolas O., *Maculinea*, 4 European spp.	+	+	–
Plebejinae			
Plebejus icarioides Bdv. + 3 addit. European spp., *Aricia* 4 spp., *Cyaniris semiargus* Rott., *Polymmatus* 9 spp.	+	+	+
Hamearinae			
Nemeobius lucina L.	–	–	–
Ancyluriinae			
Apodemia morno Felder	+	–	–

+ means present, – means absent, R means reduction stages.



Fig. 4. Part of a glandular cell ("trichogen cell") of Newcomer's organ of a lycaenid larva (*Cupido minimus*) with extremely divided nucleus. Stained with KES (aceto-carmine).

The role of Newcomer's gland

The larger glands whose external mouth is situated dorsally on the 7th abdominal segment were mentioned by Guenée (1867) and described anatomically and histologically by Newcomer (1912), Ehrhardt (1914), and Fiori (1958). Although the descriptions of these authors do not agree in detail, I found that the construction of the organ is the same in all species which I have investigated (Fig. 2). Ehrhardt noticed that the vast glandular bladders consisted of only two big cells each with one branched nucleus (Fig. 4) and not, as Newcomer and Fiori presume, of an epithelium of many small cells or a syncytium. Additional details, including the ontogeny of these organs, are given by Malicky (1969).

Newcomer's organ is not present in all species of lycaenid larvae. Members of the same subfamily, tribe or even genus may have or lack this organ (Table 1). Some species, e.g. *Strymon melinus* Hb., *Strymonidia acaciae* F. and *Fixsenia pruni* L. appear to be actually in a stage of reduction of the organ. It may be presumed that this organ was present in all ancestral lycaenids (except for some "riodinids") and has been subsequently reduced or lost in all lycaenid caterpillars where it does not occur now.

It is well known that attending ants imbibe the honey-like liquid which is exuded by the glands. The organ and its secretion plays an important role within the association. Nevertheless, the lack of Newcomer's organ in

many species suggests that the secretion of the perforated cupolas is more effective in the relationship between the two kinds of insects.

The function of the tentacles

The paired eversible cylindric organs on the 8th abdominal segment of some lycaenid larvae have been known for a long time. They may be termed "tenacles." D . . . S (1785) noted as early as the eighteenth century the "rote Wärzgen" in the larva of *Plebejus argus*. Several authors suggested that these tentacles have an odoriferous function which might signal the presence of a honey-producing caterpillar to ants. I can not confirm this suggestion. I have never noticed any significant reaction of ants to the tentacles, and I could not find any glandular structures in, on or near them. They contain only distally inserted setae of usual construction but minor size. Therefore, the function of the tentacles still must be regarded as unknown. They may be rudimental structures, developing from organs such as Ross (1964), Bourquin (1953) and Bruch (1926) found in several Ancylurinae and Hamearinae.

Which kinds of ants may be associated with lycaenid larvae in the field

In my experiments, only European representatives of Formicinae, Dolichoderinae, Myrmicinae, and Ponerinae were studied. Only five of them proved to be incapable of reacting specifically to lycaenid larvae. They were: one extremely specialized social parasite (*Polyergus rufescens* Latr.), three specialized grain collectors (*Messor mutica* Nyl., *M. rufitarsis* F., *Aphaenogaster subterranea* Latr.) and two soil-inhabiting species (*Myrmecina graminicola* Latr., *Ponera coarctata* Latr.). The majority of species investigated, such as members of the genus *Formica*, *Camponotus*, *Lasius*, *Myrmica*, *Solenopsis*, *Leptothorax*, etc. showed the same reaction in qualitative respects. Field data furnished by Downey (1962) from the Nearctic *Plebejus icarioides* (Bdv.) help confirm this, since no less than 11 different ant species of diverse taxonomic affinities were found attending one species of butterfly. In general, the ant species which attend lycaenid larvae seem to be the same ones which also attend Homoptera and which have a high-developed trophallaxis between adults and larvae. This hypothesis may contribute to an explanation of the evolution of the association between ants and lycaenids.

Which kinds of lycaenid larvae are attended by ants in the field

With the single exception of *Nemeobius lucina*, all species investigated in the laboratory induced an ant association. Several species were frequented less intensively by the ants but the behavior of the ants toward

the larvae was the same in a qualitative sense. This result does not agree with field notes, because while several kinds of lycaenid larvae (e.g. *Plebejus argus* L., *Scolitantides orion* Pall.) are never found without ants, other species have never been recorded as being ant-attended. Therefore, additional field research was undertaken which led to the idea that for the association of certain partners, a common biotope preference is most important. There is an additional preference of activity of certain kinds of ants and caterpillars for the soil surface (e.g. in *Tetramorium caespitum* L., *Lasius flavus* F., and *Plebejus argus* L.), for the herbaceous vegetation (e.g. in *Myrmica scabrinodis* Nyl. and several *Polyommatus* and *Lycaena* spp.) or for the shrub and tree stratum (e.g. in *Colobopsis truncata* Spin., *Dolichoderus quadripunctatus* L., and several Theclinae).

Exceptions

As already mentioned, the majority of lycaenid larvae and ants may be associated only in a facultative way. The caterpillars do not need the ant's presence. Nevertheless, in a few cases, close relations exist between specific lycaenids and ants. In Europe, the four species of the genus *Maculinea* are associated with ant species of the genus *Myrmica*. These caterpillars are phytophagous up to the last molt and are then carried into the ant nests by worker ants. There they live as social parasites, feed on the ant's brood, and are fed orally by the adults. This association is based upon additional adaptations. The molts take place at very short intervals so that the last molt occurs only a few days after the larval emergence from the egg. I presume that this is necessary for the accumulation of the highest number of perforated cupolas at the time when the caterpillar is ready to be carried into a *Myrmica* nest. It therefore resembles the ant larva in size, consistence and presumably odor. In addition, the critical stage to be carried into the nest is well synchronized with the activity of the host: in July and August, in the biotopes of these lycaenids, only members of the genus *Myrmica* are in full activity, because the majority of other Central-European ants have very low activity during summer. Another adaptation is that the *Maculinea* larvae perform a distinct begging behavior similar to that of the ant's larvae, which releases the feeding response in the worker ants.

In the literature several lycaenids are also recorded to have carnivorous associations, e.g. *Lachnocnema bibulus* F. (Cripps and Jackson, 1940), *Niphanda fusca* Brem.-Grey and *Spindasis takanonis* Mats. (Iwase, 1953, 1955), *Euliphyra mirifica* Holl. (Lamborn, 1914) and *Liphyra brassolis* Westw. (Chapman, 1902). However, such association depending in an obligate way on the ant's care is exceptional. Bionomical data are availa-

ble for about 800 lycaenid species, but only 10 are known to belong to these exceptions.

Principles, function and evolution of the association

The association between lycaenid larvae and ants is based upon several ethological, morphological and chemical goal adaptations of the caterpillars to the behavior and the social biology of the ants. There is no reference to any adaptation of ants to the lycaenid's habits. Some of the caterpillar's adaptations are based upon copies of signals (Signalkopien) which are important in the ant's social life. The secretion of the perforated cupolas is presumed to be similar to, or identical with, ant pheromones. The *Maculinea* larvae copy a *Myrmica* larva in size and habits. The lack of the beating-reflex and the presence of a thick cuticle are adaptations to the aggressive behavior and to the mandible construction of ants. Therefore, the biological function of the association is to protect the caterpillars from the ant's aggression. Protection from ant aggression is, however, not restricted to lycaenids. Among insects and other arthropods many ways are realized which serve the same purpose. Armoured cuticles (e.g. in many Coleoptera), dense pilosity (larvae of Arctiidae, Lymantriidae etc.), chemical repellents (Coccinellidae, Zygaenidae), construction of protecting cases (Psychid and Tortricid larvae) and other devices prevent ant aggression or render it ineffectual. In this respect, the particular association of the lycaenids is only one of several realized chances.

The evolution of this association can only be sketched in broad outlines, since the details of anatomy and histology are available only in few kinds of caterpillars. Presumably the present day larvae originate from a kind which differed from other lepidopterous larvae by its voluminous cuticle. Larvae such as *Nemeobius lucina* may derive directly from this stage. Another evolutionary pathway lead to the development of big and eversible glandular equipment similar to Newcomer's organ, which are presumed to have been serial in their earliest ancestral stage. On this evolutionary line the perforated cupolas developed which proved to be more effective than the big glands, which were subsequently modified and reduced. The result of this evolution is a caterpillar which is provided only with perforated cupolas, as it is demonstrated by species of *Lycaena* and several Theclini.

The well known carnivorous habits of many lycaenid larvae (Dethier 1927, Clausen 1962) have no connection with the above mentioned evolution. It is certain that the obligate rapacious lycaenids evolved independently from each other, originating their carnivorous habits from different levels of ant adaptation. I agree with Brues' (1936) ideas, but I can not accept the Lamarckian suggestions of Balduf (1938).

Suggestions for future work

It is highly desirable that we investigate the anatomy and histology of many additional kinds of lycaenid caterpillars, particularly additional subfamilies which are well represented in the Ethiopian, Indoaustralian and Neotropic regions. It would be very revealing to research the details of the specialized organs by means of ultra-optical methods. The chemistry of the secretions and their interrelations with ant's pheromones are still unknown and need to be investigated. The behavior of additional ant species, particularly those of other than European origin, may shed new light on these relationships.

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Summary

Comparative anatomical, histological and ethological studies in about 60 kinds of lycaenid larvae and pupae and ethological studies in about 50 kinds of ants were undertaken. The particular adaptations of the lycaenid larvae correspond with details of behavior, eidonomy and social biology of ants and are regarded as protection from the ants' aggression. Individual species of lycaenids are dependent social parasites of ants, but the majority are associated with ants only in a facultative way. True symbiosis is unknown. The evolutional pathway is suggested.

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OCCURRENCE OF *COENONYMPHA INORNATA* (SATYRIDAE) IN MAINE

It has been noted in recent years that *Coenonympha inornata* (Edwards) has been expanding its range in the northeastern portion of the United States and Canada.

On July 5, 1968 I collected a female of this species in a roadside bog between Enfield and Passadumkeag, Penobscot Co., Maine. The specimen, which was taken in the early afternoon, appeared to be about one to two days old. Poor weather conditions and a subsequent collecting trip to Canada prevented further collecting in this area.

The specimen has been determined by F. Martin Brown as being closest to *C. inornata inornata* (Edwards). As far as can be determined, this is the first record for this species in the State of Maine.

CLIFFORD D. FERRIS, *Laramie, Wyoming.*

DISTRIBUTIONAL NOTES ON THE GENUS *MESTRA* (NYMPHALIDAE) IN NORTH AMERICA

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The genus *Mestra* Hübner is of Neotropical distribution and contains six species, one of which, *amymone*, ranges northward into the United States. *Mestra amymone* (Menetries) is a breeding resident of the lower Rio Grande Region of Texas, but has been frequently recorded as a "stray" far north of here (figure 1).

Many tropical species, such as *Phoebis philea* (Johansson), are noted for sometimes "straying" far northward, but the records for *Mestra amymone* differ from all others in one important respect, the frequency of multiple captures in the extra-normal range. Records of tropical butterflies, in regions considerably north of their normal range, consist almost exclusively of single captures; yet nearly 50% of similar records for *Mestra amymone* are for multiple captures. This is significant because it may indicate that *M. amymone* is actually breeding in many of the areas where it has been found.

The reported foodplant for *Mestra amymone* is a species of *Tragia* (family Euphorbiaceae), a plant commonly known as "Noseburn" (because of an effect the plants are alleged to have on livestock) or, in Mexico and parts of the Southwest, as "Chichicastle." Most workers have excluded any possibility of *M. amymone's* breeding north of its normal range on the assumption that its foodplant, *Tragia*, is not available. Brown (1957) for example, says: "There is no chance that this species will become naturalized in Colorado. It is a tropical butterfly that breeds as far north as southern Texas. Its foodplant, *Tragia*, does not grow in this region." Johnson (1962), however, refers to the genus *Tragia* as ". . . widespread in the arid grasslands and brush of northern Mexico, north to Arizona, Colorado and Kansas. . . ." It is possible then that *M. amymone* can breed on *Tragia* far north of southern Texas.

Noseburn is a small plant with small staminate flowers in racemes, narrow serrate leaves and trailing vine-like stems covered with stinging hair. Nine species and varieties of North American *Tragia* have been described, but modern workers, such as Johnson (1962), McVaugh (1961) and Shinners (1961), concur that they all belong to a single variable species, *neptifolia* Cavanilles. The approximate recorded range of *Tragia*

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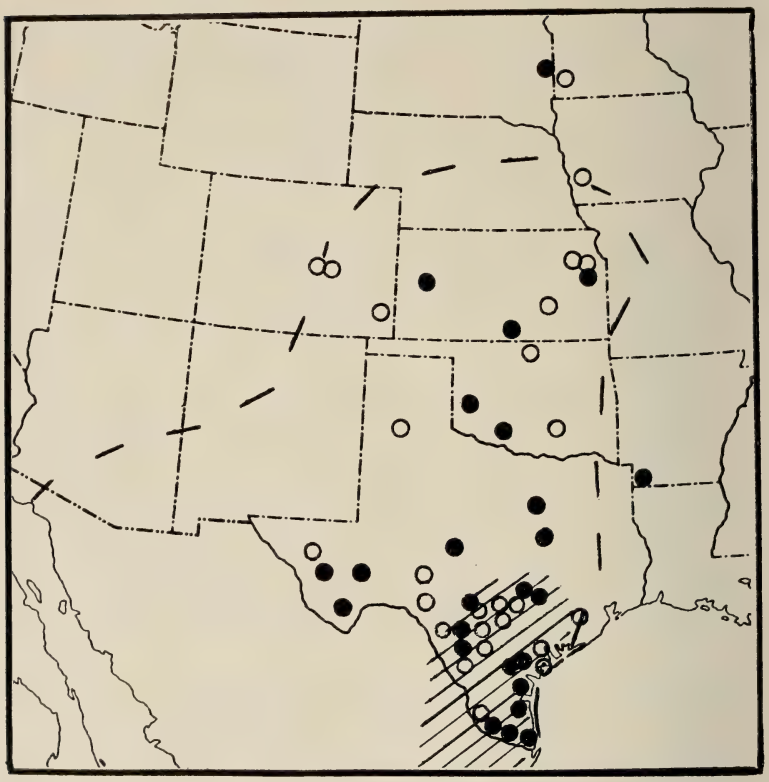


Fig. 1. Distribution of *Mestra amymone* (Menetries) in the Great Plains Region of the United States. Solid circles indicate multiple captures (more than one specimen in the same year); open circles, single captures. The cross hatched area indicates the approximate permanent breeding area. The hashed line traces the approximate northern limits of *Tragia neptifolia* Cavinilles, the larval foodplant for *M. amymone*.

neptifolia in the United States has been traced (hashed line) on the map (fig. 1), it encircles most of Texas, Oklahoma and Kansas plus parts of Arizona, New Mexico, Colorado, Nebraska, Iowa and Missouri—enclosing all but three of the U.S. records for *Mestra amymone*. Within its range, *Tragia neptifolia* occurs in almost all habitats from sea level to 8000 feet, but is most abundant on rangeland at moderate elevations.

Until early stages are collected, there will be no proof that *M. amymone* breeds north of Texas; in the meantime, the most convincing "circumstantial" data that it does, comes from Reed (1913) who writes: " . . . in the summer of 1907, I found quite a large colony of them [*Mestra amymone*] near Cordell, Washita County [Oklahoma]. I took specimens over a range of about eight or ten miles in extent. They were permanently located and

were breeding." Other records of multiple captures dot Oklahoma and Kansas and there is a multiple record for South Dakota. We must assume that *M. amymone* does indeed occasionally breed on the Great Plains, but is unable to overwinter and become permanently established.

Mestra amymone is a weak flying species usually found in open areas, and along roadsides and the edges of woods and is easily captured in flight or at flowers. W. H. Howe (*in litt.*) has taken specimens in bait traps near Ottawa, Kansas. Unlike most of the migratory butterflies it is not a strong flier and in fact seems to be so fragile as to be unlikely to survive being swept great distances by sheer force of the winds. I am of the opinion that in some years overpopulation or drought may cause a shortage of food in the normal range of the species, and the butterflies disperse northward looking for foodplant. This theory would help explain the frequency of records from widely separated areas in the same year, i.e. Colorado Springs and Ottawa in 1950.

Records for *Mestra amymone* taken north of Texas may be summarized as follows:

ARKANSAS: I took five specimens in less than an hour's collecting near Texarkana, Miller County on August 31st, 1963.

COLORADO: Brown (1957) cited a specimen taken by Norman Marston at Hartman, Prowers County, one by himself in Bear Creek Canyon, near Colorado Springs, July 4th, 1950, plus a possible site record near Jimmy Camp Creek, southeast of Colorado Springs.

IOWA: The only Iowa specimen of *M. amymone* is an undated specimen taken by Dr. L. G. Stempel near Macedonia and reported by Lindsay (1917).

KANSAS: Calkins (1932) recorded several specimens from Scott County in August and September of 1931; Field (1938) reported records from Sumner, Greenwood and Shawnee counties; Overman (1914) reported a specimen taken during October 1904 near Lawrence, Douglas County; Howe (1958) reported eight specimens taken at Ottawa, Franklin County during 1950.

MINNESOTA: A single museum specimen has been located bearing the data: "Pipestone, Minn. 1894." This specimen may have originated with Truman who made his collection at Volga, South Dakota (actually not far away) at approximately this time. The present location of the Truman collection is unknown.

NEBRASKA: The popular butterfly guides (i.e. Holland, 1930; Klots, 1951; and Ehrlich & Ehrlich, 1961) all record *M. amymone* as straying north to Nebraska. However, Leussler (1938) excluded it from his state list for Nebraska and there are no other published records from the state. I have been unable to locate any specimens in museum collections. Ne-

braska specimens will no doubt be collected at some date in the future; in the meantime, it can be assumed that those specimens collected in Minnesota, Iowa and South Dakota either migrated through Nebraska or are progeny of butterflies that did.

OKLAHOMA: Reed (1913) stated that *M. amymone* was a rare species in Oklahoma, but could be found by the careful collector in almost any year; his records include Washita (1907), Ponotoc (1905) and Kay (1911) counties. The butterfly was also taken in moderate numbers in Comanche County in 1950 and again in 1954.

SOUTH DAKOTA: Truman (1896) listed *Mestra amymone* among the species that he had taken at Volga, South Dakota; undoubtedly these were taken in a single year, probably 1894.

There are no known records of *Mestra amymone* for Arizona, New Mexico or Missouri; *Tragia neptifolia*, the foodplant, occurs in these areas and the butterfly may eventually be found as well. There is also a remote possibility that specimens of *M. amymone* will turn up eventually in Wyoming or Louisiana. Distributional data for Texas and Central America follow:

TEXAS: Gooch & Strecker (1924) recorded *Mestra amymone* as double-brooded and very common at Waco, McLennan County, and this is apparently the most northerly point where *amymone* has been known to overwinter. Roy O. Kendall of San Antonio, Texas supplied me with a list of all Texas localities at which *M. amymone* has been collected; these include Aransas Bandera, Bee, Bexar, Bastrop, Brewster, Cameron, Comal, Crockett, Culberson, Dallas, Dimmit, Frio, Harris, Hidalgo, Jeff Davis, Jim Wells, Kendall, Kerr, Kinney, Kleberg, Live Oak, McLennan, Medina, Pecos, San Patricio, Starr, Tom Green, Swisher, Travis, Uvalde, Val Verde, Victoria, Zapata and Zavala counties. As can be seen by the map (fig. 1) these show a very strong concentration in the lower Rio Grande Valley.

MEXICO: Hoffman (1940) cited the Mexican range of *M. amymone* as temperate and hot areas over almost all of the Republic. Actually the butterfly seems to be present throughout central and southern Mexico at low or moderate elevations, but in northern Mexico is confined to that area east of the Continental Divide.

CENTRAL AMERICA: The southern limit of *Mestra amymone* in Central America is not known. It has been taken in Guatemala and British Honduras by E. C. Welling and in El Salvador by M. Serrano. It probably reaches Nicaragua and Costa Rica but, along with other members of the genus, seems to be absent from Panama (Dyar, 1914; Huntington, 1932; G. Small, *in litt.*). In South America, *Mestra* is represented *M. bogotana*

Felder and other species; the range "gap" in Panama does not seem to be due to a lack of available foodplant.

Records of *Mestra* from Florida are undoubtedly erroneous despite the fact that Strecker described *Cystineura* [*Mestra*] *floridana* from the Everglades. According to Fox (1942), Strecker "deliberately misquoted the locality and number of specimens in order to conceal the fact that he had used the Mengel series for his description". Twelve specimens in the Mengel Collection originated with Fred de Hart and bear the data label of "Crystal River, Florida" [Citrus County?], a locality 70 miles north of Tampa. Kimball (1965) removed *M. floridana* from the Florida list and presumed either that they were not taken in Florida or that they may have represented an isolated colony that was wiped out by the freeze of 1899. This second theory is extremely doubtful because there is no foodplant, *Tragia*, available in Florida. *M. floridana* is identical in appearance to *Mestra bogotana cana* Erichson of Trinidad, and the most plausible explanation is that the Mengel specimens originated there and were mislabelled. *Mestra bogotana* extends northward in the Antilles only to St. Lucia and Dominica. A third *Mestra, dorcas* Fabricius, is found between here and Florida on Jamaica. *Archimestra teleboas* Menetries, which was formerly placed in *Mestra*, occurs in the Antilles also. Although *Mestra floridana* still appears in our North American checklists (i.e. dosPassos, 1964), I am of the opinion that it should be "sunk" as a synonym of *cana* and removed from future checklists.

Without getting in a discussion over the need for or the value of vernacular names, it is interesting to mention that there is an old name, "The Texas Bagvein", that has not been used for *Mestra amymone* since the 1930's. It is certainly a more imaginative name than "The Amymone" which is currently in use in field guides.

I appreciate the assistance of Dr. George Wallace of the Carnegie Museum and Dr. Frederick Rindge of the American Museum of Natural History for allowing me access to their collections to obtain distributional data, and of Roy O. Kendall of San Antonio, Texas for supplying me with detailed distributional data for *M. amymone* in Texas.

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FREEMAN COLLECTION OF MEGATHYMIDAE DONATED TO THE AMERICAN MUSEUM OF NATURAL HISTORY

For the past 30 years Mr. H. A. Freeman has concentrated on the Megathymidae. During this period he has worked out the life histories and food plants of most of the species and subspecies in this family, and he has named many of these. His magnificent collection, containing 2353 specimens, nearly all of them reared from the early stages, has been donated to the American Museum of Natural History. It includes nine holotypes, 14 allotypes, one neallotype, and 638 paratypes; 76 genitalic preparations and a large number of pupal cases are also included. All of Freeman's primary types of the Megathymidae, with one exception, are now in the collection of the American Museum of Natural History. This generous donation gives the American Museum one of the largest and most complete collections of this family in existence.

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THE EFFECT OF PHOTOPERIOD ON THE TERMINATION OF PUPAL DIAPAUSE IN THE WILD SILKWORM, *ACTIAS LUNA*[1]

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Williams and Adkisson (1964) have demonstrated that photoperiod controls the termination of pupal diapause in the silkworm, *Antheraea pernyi* Guérin-Ménéville. For example, at 25° C, short-day conditions (4- to 12-hour photophases) strongly inhibit the termination of pupal diapause, while long-day conditions (15- to 18-hour photophases) promote the termination of diapause. The experiments which follow were carried out to determine if photoperiod also controls the termination of pupal diapause in the silkworm, *Actias luna* Linnaeus.

The first two experiments were carried out to determine the effect of photoperiod on previously chilled pupae. Sixty *A. luna* pupae were purchased from Butterfly Art Jewelry, Inc. on January 3, 1967 (I was told that these were raised and stored outdoors). They were kept in the garage where it was cool, until January 10 and then divided equally among four 2 pound coffee cans. Each can was covered with mosquito netting and immersed to a depth of about 2 inches in a fish tank of water. A constant temperature heater kept the water at 26–28° C. The containers were exposed to photophases of 0, 11, 16, and 24 hours. The 11-hour and 16-hour photophases were achieved by covering the containers with 3 pound coffee cans at 6 P.M. and 11 P.M. respectively and removing these at 7 A.M. The 0- and 24-hour photophase containers were left covered and uncovered respectively. Each of these latter cans was painted black on the inside and placed so that air but no light could get in. The whole set-up received illumination from two 40 watt GE F400W fluorescent cool white lamps hung about 4 feet above the containers.

Pupae exposed to the 11-hour and 16-hour photophases emerged as adult moths in an average of 17 days. The pupae exposed to continuous darkness emerged in an average of 19 days and those exposed to continous light emerged in an average of 20 days (Table 1). The fact that the first of these adults emerged in only 6 days as against 17 days in the following experiment suggests that many were no longer in diapause at the start of this experiment. If it can be assumed that those moths that emerged on or after the seventeenth day were all in diapause at the start of the experiment, the comparative times of emergence were such as to suggest that photoperiod was not an important factor.

[1] Part of a project which won the $8000 second prize in the Westinghouse Science Talent Search, Washington, D.C., 1969.

TABLE 1. TOTAL ADULTS EMERGING FROM COMMERCIAL PUPAE[a]

Days	0-hour Photophase	11-hour Photophase	16-hour Photophase	24-hour Photophase
6	0	1	0	0
7	0	1	1	0
8	0	2	1	0
9	0	2	2	2
11	2	2	2	3
12	5	3	2	3
13	5	3	2	5
14	6	4	5	7
15	7	5	7	8
16	8	7	8	8
17	8	8	9	9
18	8	9	9	10
19	9	9	9	10
20	10	9	10	10
21	10	10	10	10
23	10	10	11	10
24	11	10	11	10
26	11	10	12	10
29	11	11	12	10
30	11	11	12	11
31	12	11	12	12
34	13	11	13	12
35	14	12	13	12
39	14	12	13	13
40	14	12	13	14

[a] The remaining specimens were dead.

TABLE 2. TOTAL ADULTS EMERGING FROM PUPAE IN DIAPAUSE[a]

Days	11-hour Photophase	16-hour Photophase
17	0	2
18	2	2
19	3	2
20	5	3
21	6	5
22	7	5
23	8	5
24	8	6
26	9	6
34	10	6
37	10	8
40	10	9
43	10	12
44	12	13
46	12	14
47	13	14
49	14	15

[a] The remaining specimens were dead.

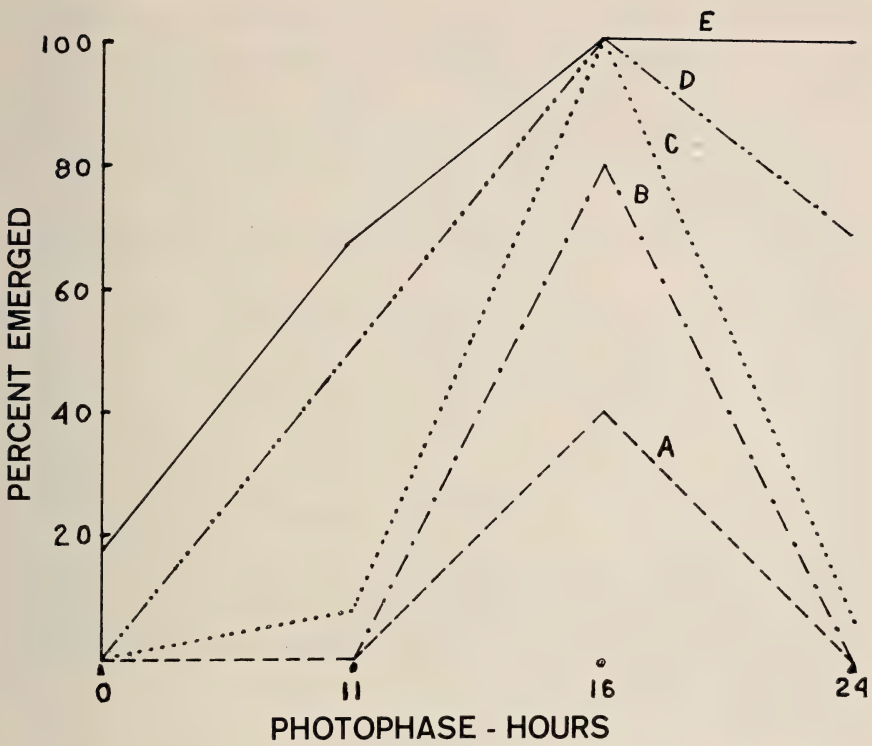


Fig. 1. The effect of photoperiod on the termination of diapause in the pupae of *Actias luna* not previously chilled. Percentage emergence after: A, 8 weeks; B, 13 weeks; C, 18 weeks; D, 23 weeks; E, 28 weeks.

In the second experiment *A. luna* larvae were raised under an 11-hour photophase as previously described by Wright (1967) to assure that all pupae were in diapause. The cocoons were stored in the garage, still under 11 hours of illumination, from June until February 28 so that they would be exposed to a period of low temperature before emergence. On February 28, 15 pupae were put into each of two 2-pound coffee cans. The procedure was essentially the same as that in the first experiment except that a bath temperature of 24–25° C and photophases of 11 and 16 hours were used.

The pupae exposed to the 16-hour photophase emerged as adult moths in an average of 33 days and those exposed to the 11-hour photophase emerged in an average of 29 days (Table 2).

A third experiment was carried out to test the effect of photoperiod on unchilled pupae. Sixty diapausing pupae were bought from Bill Shibe of

Moorestown, N. J. The cocoons were spun about September 2 and were shipped 2 weeks later. The experiment was begun on September 21. Fifteen *A. luna* each were exposed to 0-, 11-, 16-, and 24-hour photophases at 24–25° C using the same apparatus described above. The pupae exposed to the 16-hour photophase emerged in an average of 69 days and those exposed to the 24-hour photophase emerged in an average of 152 days. At the conclusion of the experiment (200 days), 67% of the pupae exposed to the 11-hour photophase and 17% of those kept in darkness had emerged (Fig. 1).

The difference in the number of days required for emergence of the adult moths from previously chilled pupae under the various photoperiods does not appear to be significant, and these experiments therefore suggest that day-length has little or no effect on the termination of diapause of overwintered *A. luna* pupae. On the other hand, the difference in the time of emergence of the unchilled pupae is significant, and we may conclude that photoperiod does play an important part in the termination of diapause of such pupae.

These results are interesting because they suggest that in *A. luna*, photoperiod is important in the termination of diapause of unchilled pupa but not of previously chilled pupae, whereas Williams and Adkisson demonstrate that in *A. pernyi* photoperiod affects the termination of pupal diapause of both chilled and unchilled pupae.

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FIELD NOTES ON THREE SKIPPERS IN TEXAS (HESPERIIDAE)

While collecting in the Rio Grande Valley-Brownsville area in southern Texas, the author took three skippers rarely taken in the United States. All were collected in the Santa Ana National Wildlife Refuge, Hidalgo County, Texas. The first, *Synapte salenus* Mabille (♀) was taken on the trail between the Old Spanish Cemetery and the Inland Lake in a shaded, grassy, low spot on 27 August, 1968. *Pyrgus albescens* Hoetz (♂) was captured in a clearing at the river end of West Gate Road, 29 August, 1968. A female *Pyrgus communis* was also taken at the same time and place. On the foot-trail between West Lake and West Gate Road, on 19 October, 1968, *Celaenorrhinus stallingsi* Freeman was taken when it settled on a low plant growing in a patch of sunshine coming through the trees overgrowing the trail. This is the second United States record for this species. Determinations were made by H. A. Freeman, Garland, Texas.

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COMMENTS ON FORMS OF *GONEPTERYX ASPASIA* (PIERIDAE) DESCRIBED BY SHU-ITI MURAYAMA

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The initial reason for writing this paper was to attempt a revision of the the forms of *Gonepteryx* described by Prof. Dr. Shû-iti Murayama of Ibaraki, Osaka-fu, Japan, with the aid of ultraviolet photography in order to determine their real position within the system for the genus, worked out in a recent monograph (Nekrutenko, 1968). In addition to this, it will be useful to express here some taxonomic suggestions, which I hope will show the correct position of the forms considered.

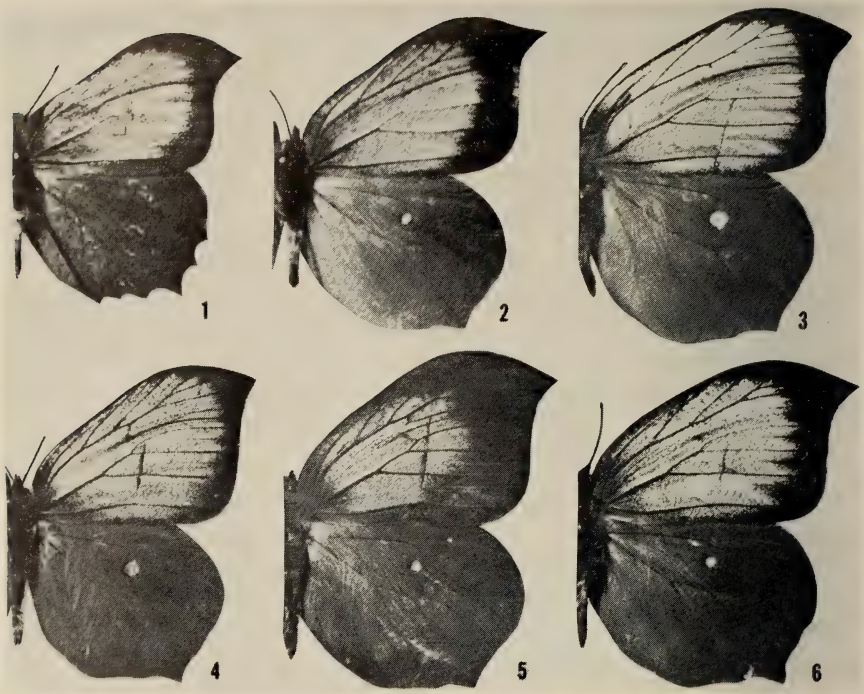
I quote Murayama (1964):

". . . Bisher wurde *aspasia* aus dem Amur- und Ussuri-Gebiet als Synonym von *mahaguru* Gistel gedeutet. *Aspasia* ist jedoch oberseits beim ♂ am Vorderflügel, den heller gelben Saumbereich ausgenommen, tiefer gelb, ist grösser, und hat die Hinterflügel weniger tief gezähnt. Daraus ergibt sich, dass *aspasia* sicherlich nur eine gute Subspezies von *mahaguru* sein kann."

I offer some comments concerning this combination:

(1) *Gonepteryx mahaguru aspasia* of Murayama (1964) is not a new combination. Hemming in 1935 suggested that *aspasia* is a subspecies of *mahaguru*, taking as type locality "montagnes de Chingan jusqu'a Khokhtsir".

(2) The question of the relationship between the names *aspasia* Ménétriès and *mahaguru* Gistel is worthy of more detailed discussion. The source of confusion here lies in the fact that, as was pointed out by Hemming (1935), Gistel's paper (1857) was unknown to his contemporaries and was overlooked by his successors, so that the names he proposed have never been brought into use. Search of the literature shows that there are four principal viewpoints on this subject: (i) *mahaguru* and *aspasia* are two names for the same species, and because the former is older than the latter (1857 versus 1859), *aspasia* is to be rejected; (ii) *aspasia* is a subspecies of *mahaguru*, which is in its turn, a senior synonym of *zaneka* Moore, 1865 (Talbot, 1935); (iii) *mahaguru* is a subspecies of *aspasia* (Hemming, 1935, et al.); (iv) *mahaguru* and *aspasia* are distinct species (Nekrutenko, 1968). The synonymy of *mahaguru* to *zaneka* is perfectly clear. Comparison of the texts of Gistel's (1857) and Moore's (1865) de-



Figs. 1–6. Hidden wing-pattern of males of *Gonepteryx* spp. 1, *G. mahaguru* Gistel, Kulu (Coll. Zool. Inst., Leningrad); 2, *G. aspasia aspasia* Mén. Amur, Radde, 22.VII. 1912. G. Kotshubey leg. (Koll. Zool. Mus. Kiev University); 3, *G. a. niphonica* Vty., Mt. Daisen, Prof. Tottori, Japan, 9.VII.1959 (Coll. Murayama); 4, *G. a. iwateana* (Murayama), Paratype. Jôjôji near Morioka, Pref. Iwate, Japan, 30.VII.1954 (Coll. Murayama); 5, *G. a. coreensis* (Murayama), holotype, Kwangnung near Seoul, Central Korea, 12.IX.1959 (Coll. Murayama); 6, *G. a. kansuensis* (Murayama), Paratype, Kansu mer., Hsio Nganshan, 3000 m, Juli (Coll. Murayama).

scriptions show that they are both based on the same species from Himalaya, and that both are distinct from the form described by Ménétriès (1859).

G. aspasia and *mahaguru* are two separate species, and, thus all forms described by Murayama under the specific name of *mahaguru*, really belong to *aspasia*. Let us now consider their hidden wing-pattern (for method and terminology see Nekrutenko, 1964, 1968).

Gonepteryx aspasia iwateana (Murayama, 1964)

Original description. "Kleiner als ssp. *niphonica* Verity. Beim ♂ ist oberseits der gelbe Farbton satter, und zieht, den Saumbereich ausgenom-

men, mehr ins Orange. Der Apex des ♀ springt etwas schwächer vor, der rote Fleck am Zellschluss ist klein."

Hidden wing-pattern (Fig. 4). *Zona opaca marginalis* of the forewing narrow, far narrower than in other subspecies of *aspasia*. *Macula lucida centralis* on the hind wing is not bright, but rather grey, and sharply limited. This subspecies, with its orange forewing color which is well correlated with a narrowing of the dark elements of the hidden wing pattern, is unique within the *aspasia* group.

Occurrence. The subspecies was described from northern Japan (Praef. Iwate). No additional distributional data are available.

Gonepteryx aspasia coreensis (Murayama, 1965)

Remarks. Murayama suggested (personal communication) that this subspecies is a synonym of *aspasia f. pultaina* Doi (1929). Such a suggestion seems questionable for the following reasons: (1) G. *pultaina* was described as a spring form of *aspasia*, and specimens on which Murayama based his description were collected from April to September. (2) The main diagnostic character to distinguish *pultaina* are clearly visible fuscous spots on the underside of both wings. The latter character raises the question as to whether *pultaina* is a senior synonym of *f. guttifera* Mell (1943) which has very similar spots. Similar "guttiferous" aberrations were also found among normal specimens of *aspasia niphonica* by Murayama and of *G. rhamni* by the author. The presence of these spots may be explained, I think, by effect of environmental conditions on the overwintering insect. Thus the presence of the spots does not relate to the taxonomic position of a given specimen. Morever, the presence of the spots has not been pointed out in Murayama's description (see below), nor by this author when discussing the holotype of *coreensis*.

Original description. ". . . Ground colour of upperside in male more light yellow than (in) *niphonica* Verity, hindwing paler yellow than in forewing. The subspecies *aspasia* from Ussuri and North Korea is fairly smaller."

Hidden wing-pattern (Fig. 5). *Zona opaca marginalis* wide, wider than in all other subspecies, occupying more than half of wing surface. *Macula lucida centralis* of hindwing small, sharply limited, bright, clearly recognizable.

Occurrence. Central Korea, probably down to the southern shore of the Korean peninsula.

Gonepteryx aspasia kansuensis (Murayama, 1965)

Original description. "The Chinese form, collected in Hsio, Nganshan, Kansu is very allied to *coreensis*, but yellow ground colour of upperside in

male somewhat deeper, the projecting angle of hindwing more distinctly sharp and outer margin of that more dentate."

Hidden wing-pattern (Fig. 6). *Zona opaca marginalis* of forewing somewhat wider than in *niphonica*, deeply penetrating into *area lucida superior* between veins. *Macula lucida centralis* of hind wing small, of nearly same size as in *coreensis*.

Occurrence. Northern slope of the Kwen-lung mountain system, on the border with Gobi desert.

Discussion and Conclusions

(1) All forms described by Murayama are valid subspecies, and the study with ultraviolet rays supports their subspecific status within the the species *aspasia* Mén.

(2) In the present state of our knowledge of variation in *G. aspasia*, *iwateana* and *coreensis* appear to be extreme forms in an array of subspecies with different degree of development of single elements of the hidden wing-pattern.

(3) As was established for other than species of the *aspasia*-group of *Gonepteryx s. str.*, orange wing coloration is strictly correlated with reduction of the dark elements in the hidden wing-pattern. Such forms occur under warm and wet climatic conditions. The forms considered show a similar interrelation between visible wing color and hidden pattern in representatives of *aspasia*-group, but the environmental conditions on which these characters depend are reversed from those for the *rhamni*-group. *G. aspasia coreensis* has far broader dark zones in its hidden wing-pattern than *aspasia aspasia* from the far-eastern U.S.S.R. (Fig. 2); the hidden wing-pattern of *aspasia iwateana* from northern Japan is decidedly brighter than that of *aspasia niphonica* inhabiting the southern parts of Japan. This puzzling phenomenon cannot yet be explained, because only extensive material will provide a solution to the problem of direction of evolutionary changes, and perhaps also provide a pattern of geographic variation within the group.

(4) The slight hind wing dentition in *aspasia kansuensis* may be evidence of a close relationship between *aspasia* and *mahaguru* (Fig. 1), but once again the question arises as to which of these two species is the more primitive.

Acknowledgments

I want to thank Dr. Shû-iti Murayama who kindly assisted me in this survey by lending his type specimens and providing information not contained in his descriptions. I am grateful to Dr. Jerry A. Powell for his re-

marks and criticisms, and to Dr. D. F. Hardwick who edited and corrected the manuscript.

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NEW SPHINX MOTH RECORD FOR THE UNITED STATES

A high school student, Mr. Thane Hodson of Ottawa, Kansas found a huge moth seated on his back porch light on August 14, 1969. Mr. William D. Field, curator of insects at the United States National Museum, identified the moth as a male specimen of *Protoparce albiplaga* (Walker). The moth was evidently a windborne example from the neotropics. Many other tropical species such as *Pholus labruscae*, *P. vitis*, *Erynnis ello*, *E. alope*, *Erebus odora*, and *Thysania zenobia* (see season summaries) have all been taken at Ottawa during previous summers. However, this is the first time that *Protoparce albiplaga* has been taken in the United States. It is a Brazilian species normally occurring no farther north than southern Mexico. The specimen, in nearly perfect condition, has been deposited in the United States National Museum.

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A NEW SUBSPECIES OF *GONEPTERYX RHAMNI* FROM TIAN-SHAN MOUNTAINS, U.S.S.R.

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When compiling the recent monograph of the genus *Gonepteryx* (Nekrutenko, 1968), I felt the lack of material from areas surrounding the great mountains of Asia, and some gaps still remain in the geographical scope of this survey. Consideration of modest amount of material available from Tibet and the Himalayas showed this area to be a center of subspecific diversity of *Gonepteryx rhamni* (L.). However, there was no material from the neighboring mountain areas of Pamir and Tian-Shan, so that trends in the geographic variation of *G. rhamni* could not be detected.

This paper is based on material kindly collected on my request by Dmitri S. Lastochkin of Kiev. Examination of these specimens showed that in the Tian-Shan Mountains, or more exactly, in Alma-Ata vicinity, occurs a population of distinctive individuals which I now describe as a new subspecies.

Gonepteryx rhamni tianshanica Nekrutenko, **new subspecies**

Decidedly larger than specimens of nomenotypic race from Scandinavia and adjoining areas of western Siberia (alar expanse 55–60 mm versus 40–50 mm in *G. rhamni rhamni*).

Male: Ground color bright, vivid, lemon-yellow; orange discal spots large, about 2 mm in diameter, easily recognizable. Hairs on thorax and abdomen whitish, brighter than in *G. rhamni rhamni*. Underside of wings yellow, silky-smooth.

Superficially very close to *G. rhamni transiens* Verity of southern Europe.

Female: Ground color greenish, discal spots of same size and color as in male.

By hidden wing pattern (reflected ultraviolet)[1] this subspecies is closer to *G. rhamni rhamni* than to *G. rhamni transiens*. Forewing *zona opaca marginalis* wide, especially in anal area. Reflected elements of hidden wing-pattern on hind wing expressed poorly, diffused, in some specimens absent.

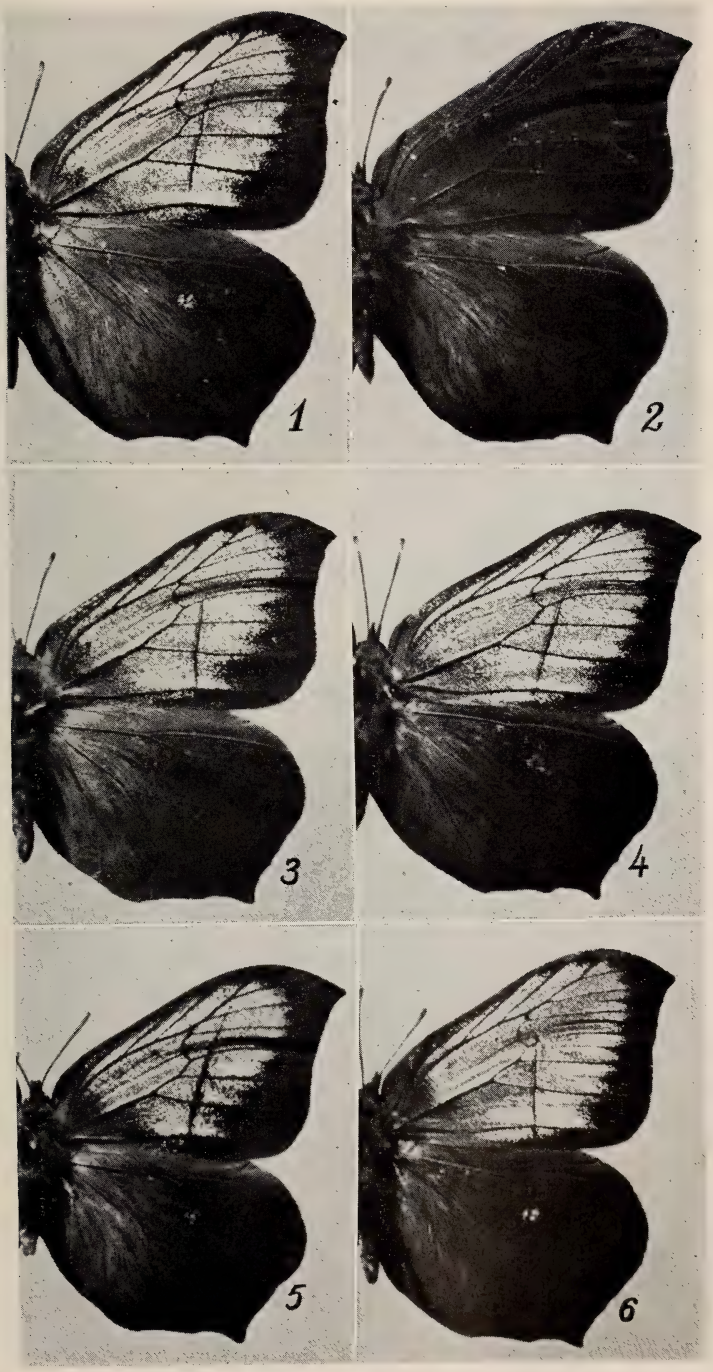
Female showing no reflected ultraviolet, appearing dark in the photographs.

Holotype male: Union of Soviet Socialist Republics, Pravy Talgar, Tian-Shan Mts., 1500 m, Alma-Ata prope, 8–12 July 1967 (D. S. Lastochkin) (Plate, fig. 1). Allotype female: Same data (Plate, fig. 2). Para-

[1] For method of material treatment and terminology see Nekrutenko, 1964.

→

Figs. 1–6. Hidden wing-pattern of *Gonepteryx rhamni tianshanica* Nekrutenko; 1, holotype; 2, allotype; 3–6, paratypes.


1
2
3
4
5
6

types: 17♂♂, 10♀♀, same data; 4♂♂, 1♀ Zailijski Ala-Too, Tian-Shan Mts., Tugok-su, 2500 m, 7 July 1968 (A. Kozubowski) (ex coll. D. S. Lastochkin).

All material deposited in the collection of Ukrainian Research Institute for Plant Protection, Kiev; 2♂♂ and 2♀♀ paratypes forwarded to Deutsches Entomologisches Institut, Eberswalde, D.D.R. (East Germany).

Comparative notes. As was stated, *G. rhamni tianshanica* occupies an intermediate position between *G. rhamni transiens* and *G. rhamni rhamni*. To the former it is closer by visible characters, to the second by characters of the hidden wing pattern. Taking this into account, we can see that *G. r. transiens* is a western form intermediate between *G. rhamni rhamni* and *G. rhamni meridionalis* Röb., another described subspecies transitional between *G. rhamni rhamni*, or its Siberian form, and *rhamni nepalensis* Dbld. When material from the Pamir Mountains becomes available, the correct position of *tianshanica* in the system of West Palearctic forms of *G. rhamni* will become even clearer.

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HOST-PLANT FINDING BY ODOR IN ADULT *CORYPHISTA MEADI* (GEOMETRIDAE)

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Introduction

The barberry geometer, *Coryphista meadi* (Packard), is a monophagous geometrid which completes its life cycle on *Berberis* L. (barberry) (Dyar, 1902; Comstock, 1967). Ranging across the U. S., it is locally common where barberry is common. The species is multivoltine and in the Northeast occurs from June through September.

By day, the moths rest among the lower barberry canes, and become active shortly after sunset when large numbers can be observed fluttering above barberry shrubs. In the present study, I found that most of these

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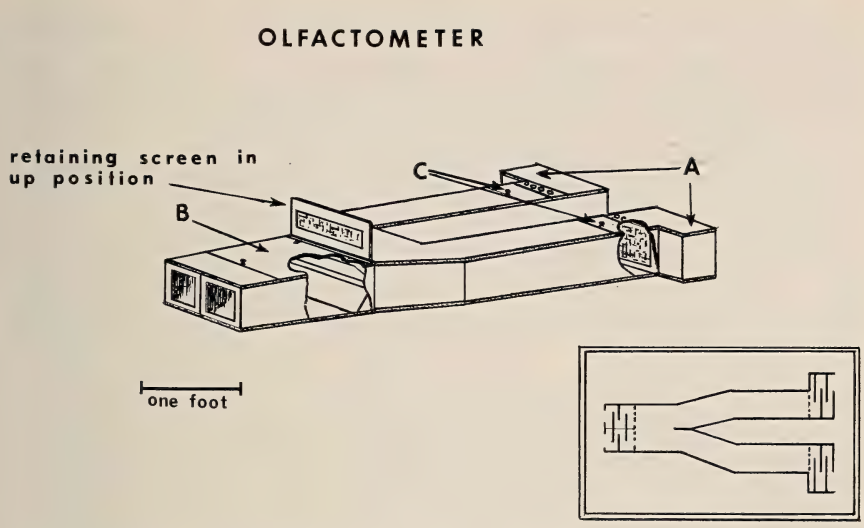


Fig. 1. "Y" olfactometer. Clippings of plants to be tested are placed at A; moths to to be tested are introduced at B; selections are determined by collecting moths at C. Inset shows the placement of light baffles.

individuals were ovipositing females. Fluttering females were seen to alight for a few moments, lay a single egg, and then move to a different portion of the barberry hedge. This ovipositional behavior continued until approximately 2200 hrs. EST, when the moths presumably moved down among the barberry canes once again.

These behavioral observations clearly suggest that barberry foliage attracts ovipositing females. Previous studies have shown that the stimuli dictating host-plant selections in a variety of Lepidoptera are chemical in nature (Beck, 1956; Gupta and Thorsteinson, 1960a, 1960b; Shorey, 1964). It was suspected, therefore, that attraction of *C. meadi* to barberry was the result of some volatile chemical or chemicals emanating from barberry foliage.

Materials and Methods

Moths collected by hand-netting shortly after sunset were placed into a Y-shaped olfactometer made of ¼ inch plywood (Fig. 1). The olfactometer was placed in a window which opened into a 10- × 13-foot room. The window was blocked in a manner which allowed passage of air only through the apparatus. An exhaust fan situated at the opposite end of the room drew air slowly through the olfactometer. Recirculation of the air was prevented by finally exhausting the air out of the room. Holes drilled in the top of each arm of the "Y" admitted natural

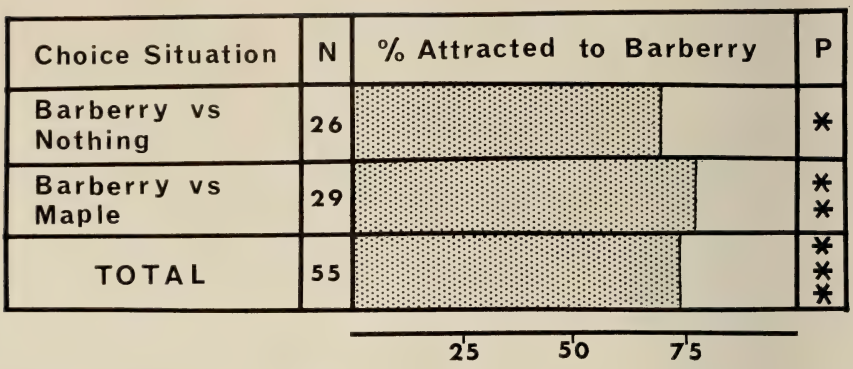


Fig. 2. Attraction of *C. meadi* to the source of some chemical or combination of chemicals emanating from barberry foliage. "Total" represents the sum of the two choice situations. Significant deviations from a chance distribution are indicated by asterisks: one asterisk, $P < 0.05$; two asterisks, $P < 0.01$; three asterisks, $P < 0.001$.

light to the ends of the olfactometer. Two or three sprigs (three to four inches long) of the plants to be tested were placed at either (or both) of the ends marked "A". Moths to be tested (7–11 per trial) were introduced at "B". A removable wire screen separated the moths from the junction of the two arms of the "Y". After the moths were introduced into the olfactometer, the fan was started and air drawn through the apparatus. The wire screen was kept in place for 30 minutes and was then removed, allowing the moths access to either of the arms of the "Y". All trials were run for approximately five hours (0000–0500 hrs. EST). The choices were noted by removing the covers, "C", and collecting the moths at both ends of the "Y".

Two separate choice situations were tested: barberry (*B. thunbergii* DC) vs. nothing, and barberry vs. red maple (*Acer rubrum* L.). All tests were run for at least four consecutive nights, alternating the control and experimental ends of the "Y" each night.

Results and Discussion

The results are summarized in Figure 2. The distributions of the moths in the two ends of the olfactometer differed significantly from random (by chi-square tests) in both choice situations ($P < 0.05$ for barberry vs. nothing, and $P < 0.01$ for barberry vs. maple. Statistical analysis of the left-right distribution of the moths showed no significant deviations from random ($P > 0.30$). The results clearly demonstrate that *C. meadi* may be attracted by a volatile substance (or substances) emanating from barberry and is capable of orienting up-wind and flying along a concentra-

tion gradient to the source of this attractant. These experimental data support the suggestion from field observations that ovipositing females are attracted to the host plant by olfaction. More interesting, however, these data indicate that *C. meadi* may have the ability to locate its host plant over comparatively long distances. The ovipositional behavior of the species (flight between the laying of each egg) perhaps serves to reduce intraspecific competition by effecting greater larval dispersal. If this is true, then the ability to locate the host plant over relatively long distances would apparently be highly adaptive because barberry under natural conditions does not normally grow in dense thickets but is scattered in patches.

This study has also indicated that the problems encountered in attempting to investigate host-plant selections using olfactometers (Thorsteinson, 1960) can be overcome. Early designs of the apparatus used in this study did not contain the light baffles shown in Fig. 1. The moths failed to make selections in these devices, apparently showing only positive phototropic responses. When all light was excluded from the apparatus, the moths merely sat in the box where they were introduced. By adjusting the light intensity entering the ends of the arms, responses to the plant clippings could be obtained. The introduction of a retaining screen further improved the responses obtained. Without the screen many of the moths introduced into the olfactometer immediately flew, at random, to either of the two ends of the "Y". This was apparently an escape response which was thwarted by keeping the screen in place for approximately 30 minutes.

Acknowledgments

I wish to thank the Massachusetts Audubon Society for granting permission to use Arcadia Wildlife Sanctuary, Easthampton, Massachusetts for collecting the moths used in this study. I would also like to thank Dr. T. D. Sargent who provided helpful criticism in all phases of this work.

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A BILATERAL GYNANDROMORPH OF *PIERIS RAPAE* (PIERIDAE)

A bilateral gynandromorph of the Imported Cabbage Butterfly, *Pieris rapae* Linnaeus, was taken September 18, 1969 at the Ithaca, New York city dump (Tompkins Co.). It turned up in a large, randomly collected sample of *P. rapae* taken for other purposes, and was not recognized as a gynandromorph until already dead. There is thus no information available on its behavior. Nearly all of the butterflies in the sample were taken in flight or on blossoms of Great Burdock (*Arctium lappa* Linnaeus).

The specimen is female on the left side and male on the right, similar to one taken in Bedfordshire, England in 1938 (S. H. Kershaw, *Proc. S. Lond. ent. nat. Hist. Soc. 1954–55*, p. 33). All secondary sexual color and pattern characteristics, including the pteridine pigments, are normally developed on the half of appropriate sex. There is no irregular mosaicism. The external genitalia are also bilaterally asymmetrical, with a somewhat aborted clasper on the male side. The internal anatomy was not studied.

A quick survey of the British aberrational literature suggests that gynandromorphs are much rarer in *P. rapae* than in at least some populations of the *P. napi* complex. Bilateral gynandromorphs also seem to be very rare in *P. brassicae* Linnaeus, though irregular mosaics are rather frequent. My specimen is the first of its kind to appear among perhaps 75,000 wild and bred *Pieris* I have examined in recent years, including some 12,000 wild *P. rapae* from the northeastern United States.

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A NOTE ON THE SYSTEMATIC POSITION OF *PAPILIO ANTIMACHUS*

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Recently, the Honorable Miriam Rothschild and Professors J. von Euw, and T. Reichstein (1970) have been able to prove the presence of cardenolide heart poisons in *Papilio antimachus* Drury. *P. antimachus* is very unusual in its appearance, with very long wings and a pattern which makes it look something like a giant *Acraea*. The unusual appearance of the butterfly, and the presence of the cardenolides (heart poisons which also

are called cardiac glycosides), led Dr. Rothschild to write to me concerning the systematic position of *antimachus*. I had not been able to examine a specimen of this unusual butterfly in the course of previous work on the higher classification of the Papilionoidea (Ehrlich, 1958; Ehrlich and Ehrlich, 1967), but Dr. Rothschild was able to arrange the loan of a specimen for dissection from the British Museum, through the courtesy of Dr. T. G. Howarth.

Papilio antimachus turns out to be a quite typical member of the family Papilionidae, subfamily Papilioninae. It conforms entirely to the diagnosis of the family (Ehrlich, 1958, pp. 336–337) with the exception of characters number 42 and 43 for which no information is available. Similarly, it agrees entirely with the subfamily diagnosis (pp. 338–339) except for character P on which no information is available. Further information on the family characters is as follows: 6, antennae close together; 11, anterior tentorial arms bearing very small crest; 13, cervical sclerites united beneath neck by unbroken sclerotic band; 15, spinasternum produced in much the manner of that of *Papilio machaon* (Fig. 34 of Ehrlich, 1958) except that areas of sclerotization heavier; 19, patagia membranous; 27, mesothoracic anepisternum not a separate sclerite; 32, caudal part of metathoracic epimeron broad; 34, postspiracular bar absent. Additional information on subfamily characters is as follows: H, prodiscrimen represented by a prominent anterior spine; L, lamella of metadiscrimen curved downward to base of furca; O, tarsal claws symmetrical and simple.

In the most recent treatment of the tribes of the Papilionidae (Ehrlich and Munroe, 1960) *P. antimachus* falls into the tribe Papilionini. At the moment the placement of *antimachus* by Munroe (1961) in the genus *Papilio* seems entirely appropriate, although examination of the early stages may require revision of the generic and tribal position.

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FURTHER EASTWARD EXTENSION OF THE RANGE OF *EUCHLOE AUSONIDES MAYI* (PIERIDAE) IN ONTARIO

Euchloe ausonides mayi Chermock & Chermock, is first known to have been collected in Ontario near the Manitoba border in 1947. Riotte (1968, J. Lepid. Soc., 22: 40) has traced the eastward extension of its range which reached Geraldton by at least 1966. In this locality he had collected extensively until 1958 without seeing it. In 1965 I collected the species on Manitoulin Island, Ontario, 330 miles southwest of Geraldton for the first time in spring. That year, and again in 1966, 1967 and 1968, this species first appeared during warm weather in the second week of May, remaining common until the month's end. No June collecting has been done, and the species has never been seen there during July. All records are from the limestone barrens in Burpee Township near the shore of Lake Huron, where the insect flies close to ground in sunny clearings in the juniper-white cedar-white spruce—poplar scrub known locally as "prairies." *Arabis drummondi*, a known host, is frequent in this habitat. Identification of the butterflies has been confirmed by J. C. E. Riotte, and two specimens taken May 13, 1968 have been placed in the collection of the Royal Ontario Museum, Toronto. It may be that the species, which is now common around Fort William, Ontario, proceeded along the north shore of Lake Superior to the east and thence to Manitoulin Island.

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COURTSHIP AND MATING BETWEEN *CHLOSYNE NEUMOEGENI* AND *CHLOSYNE CALIFORNICA* (NYMPHALIDAE)

The ranges of *Chlosyne neumogeni* (Skinner) and *Chlosyne californica* (Wright) overlap in certain areas of southern California. In many of the desolate mountain ranges of the Mojave Desert both species can be found flying together. While on a collecting trip to the Providence Mountains, I discovered that both *C. neumogeni* and *C. californica* were breeding in the area. After hiking out of Bonanza King Mine Canyon on April 20, 1969, I noticed large numbers of these two species of butterflies fluttering around flowering bushes. It was at the entrance of this canyon, at an elevation of approximately 4,000 ft., that I observed courtship between these two species. I saw battered *C. neumoegeni* males chasing *C. californica* females in the air. When these females alighted upon flowers, with spread wings, the males would hover a couple of inches above them. Later that afternoon, I began hiking towards Gilroy Canyon, about a mile south of Bonanza King Mine Canyon. Climbing down the side of a ravine into a dry streambed, I spotted two mating *Chlosyne* resting together on a flowering bush. Upon closer observation, I noticed that the two butterflies in copulation were a male of *C. neumoegeni* and a female of *C. californica.*

No examples of courtship and mating between male *C. californica* and female *C. neumoegeni* were observed in the Providence Mountains at this time. Also, *C. californica* appeared to be approximately eight times more common than *C. neumoegeni* in this region. *C. californica* seemed to be at the peak of its flight period, because more than half of the specimens captured were fresh. *C. neumoegeni* seemed to be in the latter part of its flight period, because most specimens were worn. One wonders if these factors might be partially causative of this rare phenomena of courtship and mating between two distinct species.

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A NEW FOODPLANT RECORD FOR *ECPANTHERIA SCRIBONIA* (ARCTIIDAE)

During a collecting trip to Florida in 1968 I found a larva of *Ecpantheria scribonia* (Stoll) feeding on the underside of a fern, *Polypodium aureum* L., 2 miles southwest of Satsuma, Putnam County, Florida. This larva, when collected on 31 June 1968, was in the penultimate instar. It pupated on July 26th and emerged, as a female, on 14 August 1968. The host fern is epiphytic on trees, especially palmetto, and has a subtropical and tropical distribution. A search of the literature has proven this a new hostplant record, and apparently is also the first time any fern has been recorded as a foodplant for this moth. Sidney A. Hessel kindly assisted with the identification of the fern.

As a postscript, I would like to add that I was brought a last instar larva of *E. scribonia* collected by Eugene S. Morton at Leete's Island, Guilford, New Haven County, Connecticut, on 29 October 1968. After some prolonged feeding on dandelion and plantain, it pupated; an adult female emerged on 13 December 1968. There seem to be no previous records of larvae in Connecticut. *E. scribonia* occurs further north, at least to Massachusetts and southern Ontario, but is rare in Connecticut.

Both specimens have been deposited in the Peabody Museum of Natural History, Yale University.

JOSEPH A. CONCELLO JR., *Peabody Museum of Natural History, Yale University, New Haven, Connecticut.*

CRAMBIDIA PURA (ARCTIIDAE: LITHOSIINAE) NEW FOR CANADA

During the summer 1969 two lepidopterological teams were working at the Biological Station of Queen's University, Kingston, Ontario, in Chaffeys Locks, Leeds Co., Ontario. One team was from the Royal Ontario Museum, the other from the Dept. of Biology of Queen's University (Prof. R. Harmsen). Both teams worked together in identifying and coordinating the catches from six "Black Lights," of which five were located at the station and one at Glenburnie, Frontenac Co., Ontario. The lights at the station were in rich deciduous forest, the light in Glenburnie in normal farming country.

In past years the lights at the station had attracted a few rare Lithosiinae, like *Cisthene unifascia* Gr. & Rob. This year we took for the first time at the station *Crambidia casta* Packard which was known to occur in this part of the country.

In Glenburnie, however, numerous specimens of *Crambidia pura* Barnes & McDunnough, a species never before recorded from Canada were taken. It was described from North Carolina, and Forbes (1960, Lepidoptera of New York and neighboring states, pt. IV. Cornell Univ. Agr. Exp. Sta. Mem. 371) gave its range as Minetto, New York; Lakehurst, New Jersey, and North Carolina.

In Glenburnie *Crambidia pura*, the identity of which was ascertained by genitalic dissection, would seem to have two generations, one at the end of June, the other in the middle of August.

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NOTES ON *CALLOPHRYS* (*CALLOPHRYS*) *COMSTOCKI* HENNE IN NEVADA

According to Ehrlich and Ehrlich (1961, *How to know the Butterflies*), *Callophrys* (*Callophrys*) *comstocki* Henne was known only from the Providence Mountains of San Bernardino Co., California. Thus, the discovery of this species in Nevada is an important extension of its known range. This finding was made on March 23, 1968 when Kenneth Tidwell and I were on a collecting trip in Nevada. At the time, we were collecting in the dry hills about five miles west of Goodsprings, Clark County, Nevada, just north of Wilson Pass, at about 5000′. At about 11:00 A.M., when Ken and I were exploring a large arroyo near a radio relay station, I observed a small butterfly flying in a rocky side canyon on the east facing slope of the arroyo. Though at first thought to be a skipper, closer observation revealed it to be a species of *Callophrys*. It eventually rested on a rock in the dry stream bed and was captured. Further specimens were observed sitting on rocks or on the sand. They darted up when disturbed, but would shortly return to the same spot after circling around a few times, in skipper fashion, before alighting. They showed no preference for any particular kind of vegetation. A total of 3 females and 5 males, all in fresh condition, were captured.

One specimen was later examined by Harry K. Clench who determined it to be *Callophrys* (*Callophrys*) *comstocki* Henne. As compared with Providence Mountains material, it was found to be slightly larger with darker black markings on the postmedian line of the underside.

In the same small canyon as the *comstocki* were taken, were found *Callophrys fotis fotis* (Strecker) and *Callophrys siva* (Edwards). The *C. fotis* were about as common as the *comstocki*, but preferred resting on bushes instead of the ground. A single *C. siva* was captured while sitting on a stunted juniper bush, a few of which grew along the sides of the canyon. The three aforementioned species appeared to be quite local as Ken Tidwell was unable to locate additional specimens in the surrounding area.

On the ridge above the canyon, many butterflies were found "hilltopping." Among these were *Papilio rudkini*, *Anthocaris sara inghami* Gunder, *Euchloe creusa* (Doubleday), and *Pieris sisymbri* Boisduval.

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BOOK REVIEW

A SHORT HISTORY OF THE BROWN-TAIL MOTH, by William Curtis. A Curwen facsimile edition, 1969; 18 + 12 pp., 1 coloured plate. Introductions by W. T. Stearn and D. S. Fletcher. Distributed in North America by Entomological Reprint Specialists, P.O. Box 207, East Lansing, Michigan. Price $9.30 U. S.

This is a beautifully prepared little book that will be of particular interest to the bibliophile. The edition has been limited to a run of 1,000 copies. In the facsimile reproduction of William Curtis's classical treatment of the Brown-Tail Moth, the history of an outbreak, the seasonal development of the insect, its food plants and its potential predators are discussed from the stand-point of a biologist of 1782. A biographical introduction by W. T. Stearn outlines what is known of the life of William Curtis (1746–1799), primarily a botanist but latterly an entomologist. Another introductory section by D. S. Fletcher of the British Museum (Natural History) is devoted to the taxonomic relationships of the Brown-Tail, its pest status as a forest insect, and the history of its introduction and spread in North America.

D. F. HARDWICK, *Editor.*

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Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
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by CYRIL F. DOS PASSOS

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Volume 24 1970 Number 4

IS *PAPILIO GOTHICA* (PAPILIONIDAE) A GOOD SPECIES

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Remington (1968) has named the *Papilio zelicaon*-like swallowtail butterflies from a restricted geographical range (the high mountains of New Mexico, Colorado, and Wyoming) *Papilio gothica* Remington. Since the criteria used by Remington for claiming the existence of this newly named species are chiefly genetical and ecological rather than the usually used morphological and behavioural ones, it seems desirable to examine the genetic evidence more critically than Remington appears to have done.

Genetical Evidence Obtained by Hybridization Experiments

Remington showed that *P. zelicaon* Lucas and *P. gothica* are morphologically very similar and he also indicated that a number of specimens cannot be classified unless the place of their origin is known. However, the F_1 hybrids between *P. gothica* and *P. polyxenes* Fabr. on the one hand, and *P. zelicaon* and *P. polyxenes* on the other, are distinguishable, as are the F_1 hybrids when *P. bairdi* is substituted for *P. polyxenes*.

P. polyxenes and *P. bairdi* Edwards are much blacker insects than *P. zelicaon*. They show a great reduction in the amount of yellow on both wings and body. Clarke and Sheppard (1955, 1956) have demonstrated that the marked difference between the color patterns of *P. polyxenes* and *P. zelicaon* and, in fact, between *P. polyxenes* and the yellow European species, *Papilio machaon* L., is due to the presence of a single major gene which is dominant or nearly dominant in effect. The *P. gothica* × *P. polyxenes* hybrids differ from the *P. zelicaon* × *P. polyxenes* hybrids in that those involving *P. gothica* have a reduction in the yellow markings on the upper side of the wings and on the abdomen, even more marked than in the *P. zelicaon* hybrids (Remington, 1968). Consequently, it can be concluded that the *P. gothica* insects that have been



Fig. 1. Male offspring from the mating *P. polyxenes* ♀ × *P. machaon* ♂. Three offspring are from a single mating, the fourth (top left) is from a second mating. Note that even full brothers can differ more from one another than the *polyxenes* × *gothica* and *polyxenes* × *zelicaon* illustrated by Remington.

tested contain different modifiers of the effect of the major dominant allelomorph of *P. polyxenes* from those of *P. zelicaon*. However, genetic work that has been undertaken in the Lepidoptera (Ford, 1955b; Clarke and Sheppard, 1963, 1968; Sheppard, 1969) shows that different populations of a single species and even different individuals within a population often contain modifiers having a much more marked effect than those reported by Remington. Furthermore, the F_1 hybrids illustrated by Remington show differences no more extreme and of exactly the same type as those found by Clarke and Sheppard (1955) between individuals when they hybridized *P. polyxenes* and *P. machaon* (Fig. 1). Thus, there is good reason to believe that the differences between the F_1 hybrids reported by Remington are no greater than those usually found within a single species. Furthermore, Remington's data do not suggest that the differences necessarily apply to all populations which he has designated as being composed of *P. gothica* but only to those from a limited area.

Sex Ratio in Hybrids

Remington also supported his argument by claiming that *P. gothica* and *P. zelicaon* "have different hybrid sex ratios in their crosses with *P. polyxenes, gothica* × *polyxenes* being nearly lethal for the sex of the *polyxenes* parent whereas *zelicaon* × *polyxenes* had more nearly equal sex ratio although deficient for the sex of the *polyxenes* parent." Even if Remington's claim were validated (it is not supported by his data, the statistical procedures he used being wrong) the mere fact that sex ratios can be profoundly different in reciprocal hybrid matings (Haldane, 1922) should warn the unwary that very small genetic differences may profoundly alter sex ratios in hybrids. Furthermore, even a cursory knowledge of Lepidopteran genetics would acquaint one with the fact that very different sex ratios may appear even between the progeny of sibs of the same sex when hybridization is involved. In fact, the extreme sensitivity of sex ratio to minor genetic differences in the parents is demonstrated by Remington's own data. Thus, the two crosses he reports between female *zelicaon* × male *polyxenes* show significantly different sex ratios among the progeny ($P = 0.004$, Fisher's exact test). It is because of this heterogeneity that it is illegitimate to combine the two broods as Remington has done in his Table 1B for comparison with the single cross of a female *gothica* × male *polyxenes*. If the correct statistical procedure is followed we find that one of the two *zelicaon* hybrid broods is significantly different from the *gothica* brood ($P = 0.0007$) but the other is not ($P = 0.122$). Thus, there is no evidence as yet that the two types of hybrid (those involving *zelicaon* and those involving *gothica*) generate different sex ratios. Even if such evidence is eventually forthcoming this would not indicate that the two forms are genetically very dissimilar.

Polymorphism for Larval Spot Color

Remington noted from his limited experience of wild *P. zelicaon* larvae (less than 50 independent observations) that they are polymorphic for the color of their sub-dorsal spotting. Previously, we had shown (Clarke and Sheppard, 1955, 1956) that this polymorphism is mainly controlled by a single gene. More extensive sampling in Napa, Yolo and Eldorado Counties (Sheppard, unpublished) is in agreement with Remington's view that the polymorphism is widespread in lowland Californian populations of *P. zelicaon*. On the other hand, in all of about 20 independent observations (Remington, 1968) the larvae of *P. gothica* were monomorphic, being homozygous for the allelomorph producing yellow spotting. Remington suggests that in this respect they are unusual. However,

although *P. polyxenes* is polymorphic for red spotting in some populations, as Remington states, the allelomorph responsible is often absent or at such a low frequency in *P. polyxenes* populations that these cannot be considered to be different from those of *P. gothica* with respect to the polymorphism on the available evidence. The gene frequencies in the populations of *P. zelicaon* and *P. gothica* so far reported are clearly different. However, since *P. gothica* has merely become monomorphic for a character polymorphic in other areas the difference does not indicate any profound genetic change. Parallel examples are common in the Lepidoptera in situations where there is no question of two different species being involved (Clarke and Sheppard, 1963, 1968). Even within the *machaon* group itself in North America the different frequencies of the forms *comstocki* and *clarki* in populations of *P. rudkini* Comstock may illustrate the point.

Ecological Evidence

P. gothica is strictly univoltine in Colorado, whereas *P. zelicaon,* as well as many other members of the *machaon* group, is multivoltine. This genetic difference has not yet been analyzed in detail. However, the difference is not surprising since *P. gothica* is from the high mountains where a single generation a year would seem to be ecologically advantageous. In fact, the difference from *P. zelicaon* merely suggests that both are ecologically adapted to their respective environments. Thus there are two ecotypes, as is so often found when montane or northern and lowland or southern types of a single species are compared. Examples from Lepidoptera in the British Isles which illustrate this point are the butterflies *Aricia agestis* Schiff., and *Polyommatus icarus* Rott. (Ford, 1945) and the moth *Lasiocampa quercus* L. (Ford, 1955a), the latter having races with a two year and a one year life cycle.

P. gothica also differs from *P. zelicaon* in that the larvae of the former appear to be found in nature only on *Pseudocymopterus montanus* (A. Gray) Coulter and Rose (five larvae and an unknown number of eggs reported by Remington, 1968) whereas several species of Umbelliferae are utilized by *P. zelicaon.* However, this restriction of *P. gothica* but not *P. zelicaon* to a single larval food plant, even if it is substantiated by more evidence, would not indicate that *P. zelicaon* and *P. gothica* are different species, for such ecotypic variation is common in the Lepidoptera and is found even within the *machaon* group itself. Thus, the *P. machaon* race from eastern England not only shows marked behavioural differences compared with the continental race but the larvae are confined to the milk parsley, *Peucedanum palustri* L., whereas the con-

tinental form is not so confined (Ford, 1945). This is a striking parallel within a single species to the difference reported by Remington.

All the genetic evidence presented by Remington suggests that *gothica* is only a minor high mountain ecotype of *P. zelicaon* and is not a good species in its own right. Unless evidence can be produced to show that the two forms are sexually isolated if they come together in nature (a matter that should not be difficult to study experimentally), then the use of *gothica* as a specific name should be discontinued. Its continued use will only confuse and not clarify the taxonomy of the *machaon* group. Although genetic evidence is valuable in taxonomy it must not be interpreted in a parochial way. Only if it is considered in the light of studies on other material from other lands will it be useful in clarifying taxonomic relationships. We fully agree with Remington's (1968) statement that the *machaon* group "is much too complicated for grand conclusions based on scanty breeding experiments or on specimen samples from a few distant, randomly-chosen localities."

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A NEW RECORD FOR NORTH AMERICA OF A SWALLOWTAIL BUTTERFLY (PAPILIONIDAE)

While visiting with Mr. J. E. Lipes in El Salvador, I was privileged to examine some of the material collected by him. Among his material were three male specimens of *Papilio* (*Graphium*) *philolaus* Bsd. Mr. Lipes informed me that all three were taken in Texas. However, only one specimen had complete data, which are as follows: July 21, 1958, Padre Island, Port Isabel, Cameron County, Texas, leg. J. E. Lipes. The specimen is being donated to the Allyn Foundation collection, Sarasota, Florida.

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THE LIFE HISTORY OF *PYRRHIA EXPRIMENS* (NOCTUIDAE)

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In more recent North American literature, the genus *Pyrrhia* has been included in the noctuid subfamily Amphipyrinae; genitalic characters show it to be a true constituent of the subfamily Heliothidinae, however. This relationship is substantiated by the larval habit of feeding primarily on the flowers and fruits of its host plants, and by the structure of the larva itself which is close to that of other species of the Heliothidinae (Crumb, 1956; Gardner, 1946).

There are two North American species of *Pyrrhia*: *umbra* (Hufn.) and *exprimens* (Wlk.). The latter has, until recently, been considered only a subspecies of *umbra*. For much of their respective distributions, however, the two occur sympatrically, and they differ not only in maculation and colouring but in the structure of the male genitalia. In *exprimens* the ground colour is orange-brown rather than golden as in *umbra*; in the male genitalia, both the valve and the ampulla are shorter in *exprimens* than in *umbra*.

In eastern North America, *exprimens* is generally of more northern distribution than is *umbra*. The former is distributed in southern Canada from the Atlantic to Pacific coasts. In eastern North America, it occurs southward at least to Pennsylvania, and in the west at least to Colorado. The few specimens I have from the latter state are all of the heavily suffused form, *stilla* Grt., and these may represent a distinctive southwestern race of *exprimens*.

Pyrrhia exprimens is rather a general feeder, being recorded from a wide variety of plants. Forbes (1954) listed larvae as feeding on *Polygonum*, *Desmodium*, and *Juglans*. The Canadian Forest Insect Survey (Prentice, 1962) has recovered larvae from *Populus*, *Salix*, *Rosa*, and *Prunus*. In addition to these records, there are specimens in the Canadian National Collection reared from *Althea*, *Betula*, and *Delphinium*. The species is, on occasion, a pest of delphinium in the Ottawa area, the young larvae feeding on the blossoms and boring through the unopened buds.

Although *exprimens* is obviously broadly polyphagous, the ovipositing female does seem to show definite preferences in host plant selection. A single female of *exprimens* was exposed to four sprays of plants in an oviposition container. Each of the sprays was of comparable size, and each was replaced daily in the oviposition container. Over a period of eleven days, the numbers of eggs laid on each were as follows: *Geranium* sp.,

447; *Phlox* sp., 151; *Chrysanthemum* sp., 64; *Ranunculus* sp., 33. In addition to these, 29 eggs were laid on the wads of cotton wool that secured the sprays in vials of water. Eggs were deposited singly at the apex of the food plant. In all, the single wild-caught female deposited 724 eggs.

Pyrrhia exprimens overwinters as a pupa in a cell a few inches below the surface of the ground. On the basis of records available, the species is single-brooded throughout its range.

Descriptions of Stages

The descriptions of immature stages in the following section were based on the progeny of a single female taken at Ottawa, Ontario. The rearing methods employed were those outlined by Hardwick (1958). Larvae were reared individually on cranesbill (*Geranium* sp.) at room temperature. Of 63 larvae reared to the pupal stage, 21 matured in five larval stadia, 42 matured in six stadia, and one matured in seven stadia. The estimate of variability, following the means for various measurements, is the standard deviation.

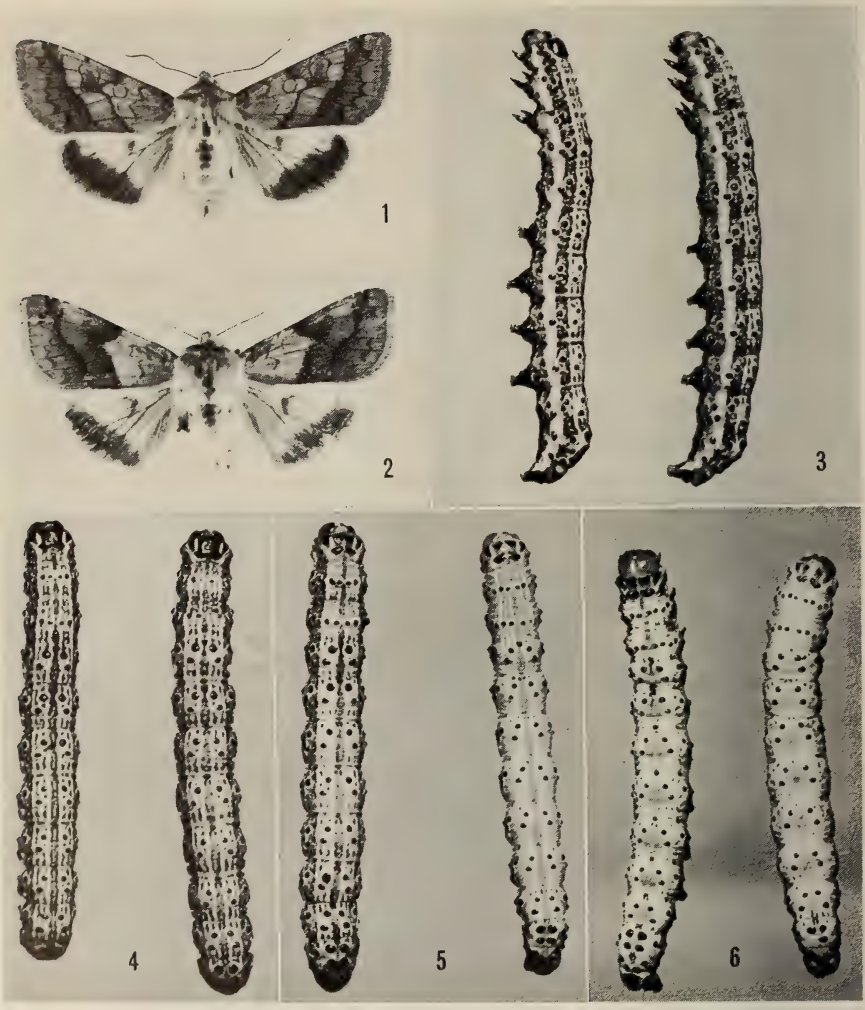
Adult (Figs. 1, 2). Ground colour orange-brown rather than golden as in *umbra*. Head and thorax clothed with mixed spatulated and hair-like vestiture. Head and thorax orange-brown, concolorous with forewing; abdomen predominantly greyish-brown dorsally. Forewing orange-brown, variably suffused with violet or reddish-brown in subterminal space and outer half of median space. Transverse anterior line forming three distinct outward angles. The anterior half of a basal line usually evident. Transverse posterior line weakly bisinuate, angling strongly inward from costal to trailing margins. Orbicular spot large, usually circular, occasionally with some dark central shading. Reniform spot large, irregular, usually darkly suffused centrally. Median line well defined, angling outward to postero-inner angle of reniform, then angling inward to trailing margin. Median space, distal to median line, variably suffused with violet or reddish-brown, occasionally heavily so. Subterminal line irregular, scalloped between the veins. Subterminal space usually suffused with violet or reddish-brown. Terminal space concolorous with basal area of median space. Usually a narrow, dark, terminal line. Fringe concolorous with terminal space. Hind wing pallid yellow, with a rather broad, chocolate-brown, outer-marginal band. A prominent brown discal lunule. A rather diffuse brown band along inner margin. Fringe pale yellow. Underside of forewing rather dark yellow with a slender, elongate, chocolate-brown basal dash, a lunate, chocolate-brown discal spot and a reddish-brown or purplish-brown subterminal band. Underside of hind wing concolorous with forewing, with a slender brown discal lunule and a rather diffuse, reddish-brown subterminal band; costal margin usually suffused with pink.

Strongly suffused form (*stilla* Grt.) with normal lines and spots evanescent except for the prominent median line; area distal to median line heavily overlaid with violet or reddish-brown.

Expanse: 35.2 ± 1.9 mm (50 specimens).

Egg. Flattened on surface opposite micropyle. Heavily ribbed on micropylar surface and on sides. Pale greenish-yellow when deposited and remaining essentially unchanged until a few hours before hatching when larval head gradually becomes visible through chorion.

Dimensions of egg: height, 0.532 ± 0.035 mm; diameter, 0.651 ± 0.028 mm (25 eggs).



Figs. 1–6. *Pyrrhia exprimens* (Wlk.). 1, 2, Adults, Ottawa, Ont. and Lethbridge, Alta.; 3, left lateral aspect of ultimate instars; 4–6, dorsal aspect of ultimate instars.

Incubation period: 5 days in all specimens observed.

First-Stadium Larva. Head very dark brown. Prothoracic shield somewhat lighter brown. Suranal shield medium to dark brown. Trunk cream or light yellow, without maculation. Setal bases and thoracic legs dark brown; setal bases large and prominent. Rims of spiracles medium to dark brown.

Head width: 0.355 ± 0.013 mm (45 larvae).

Duration of stadium: larvae maturing in five stadia, 6.9 ± 1.8 days (21 larvae); larvae maturing in six stadia, 7.0 ± 1.7 days (41 larvae).

Second-Stadium Larva. Head shiny black. Prothoracic shield dark greyish-brown. Suranal shield greyish-brown. Trunk yellow or cream and usually unmarked; a pair

of subdorsal whitish-grey lines evident in some specimens. Setal bases, rims of spiracles and thoracic legs varying from dark greyish-brown to black.

Head width: 0.561 ± 0.038 mm (63 larvae).

Duration of stadium: larvae maturing in five stadia, 3.3 ± 1.0 days (21 larvae); larvae maturing in six stadia, 3.7 ± 1.5 days (41 larvae).

Third-Stadium Larva. Head completely black, or black marked laterally and in centre of face with greyish-yellow. Prothoracic shield medium to dark chocolate-brown with a dull greenish-yellow median line and a pair of lateral greenish-yellow, submarginal patches; in a few specimens pale submarginal patches so extensively developed as to almost obliterate brown colouring. Suranal shield medium to dark chocolate-brown; in some specimens with a median, and a pair of lateral, dull greyish-yellow spots. Trunk varying from greenish-yellow to rather dark green, with a pair of pale-yellow dorso-lateral lines; middorsal band often darker than remainder of trunk. A narrow, pale-yellow, subspiracular line usually evident. Setal bases and rims of spiracles black. Thoracic legs and proleg shields dark brown to black.

Head width: 0.937 ± 0.091 mm (68 larvae).

Duration of stadium: larvae maturing in five stadia, 4.8 ± 1.5 days (21 larvae); larvae maturing in six stadia, 4.9 ± 1.4 days (41 larvae).

Antipenultimate-Fourth-Stadium Larva. Head varying from completely black, through black marked with brown laterally and in centre of face, to black with extensive greenish-fawn areas in middle of parietal lobes. Prothoracic shield greenish-yellow, typically with four anterior and four posterior black patches; black patches variably fused. Suranal shield greenish-yellow marked with blackish-brown; least maculate shield with four anterior and four posterior marginal spots. Middorsal band green, yellow, or light orange-brown, usually well defined. Subdorsal area consisting of a median band similar in colour to middorsal band and light yellow marginal lines; median band of subdorsal area variably suffused with light yellow. Supraspiracular area concolorous with middorsal band. Spiracular band light yellow, varying greatly in width and prominence. Suprapodal area concolorous with middorsal band. Midventral area paler yellow than suprapodal area. Setal bases large and black. Rims of spiracles dark brown. Thoracic legs and proleg shields dark brown or black.

Head width: 1.31 ± 0.07 mm (42 larvae).

Duration of stadium: 3.3 ± 1.6 days (41 larvae).

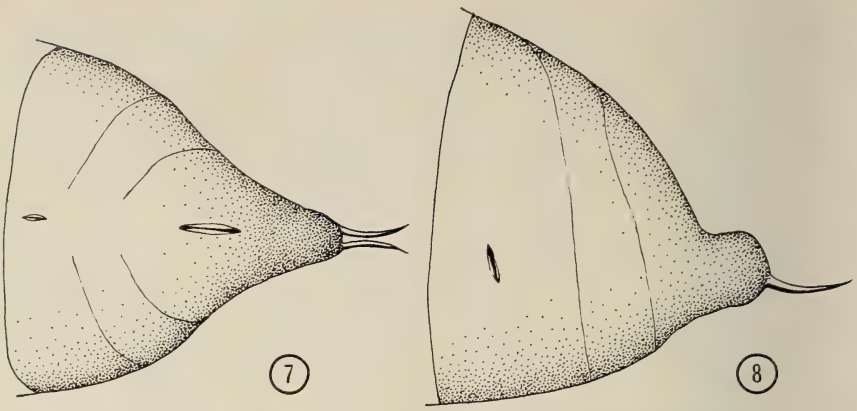
Penultimate-Stadium Larva. Head usually varying from light green to fawn and marked with black; head occasionally black marked with brown, or less commonly entirely black. Prothoracic shield pale green to greenish-fawn, marked along anterior and posterior margins with black; shield occasionally entirely black. Suranal shield usually poorly distinguished from trunk, occasionally suffused with black. Middorsal band varying from yellowish-fawn through yellowish-green to bluish-green; usually a faint, discontinuous, pale-yellow median line through middorsal band. Subdorsal area yellow with a variably defined, darker, median band; median band similar in colour to middorsal band, variably suffused with yellow and with a broken and irregular median line; median band of subdorsal area often so heavily suffused with yellow as to almost obliterate darker colouring. Supraspiracular area concolorous with middorsal band, variably and irregularly marked with white or pale yellow. Spiracular band shades of yellow, usually bright yellow and prominent. Suprapodal area similar in colour to middorsal band but paler. Midventral area paler than suprapodal area. Setal bases large and black. Rims of spiracles dark brown. Thoracic legs and proleg shields dark brown or black.

Head width: 1.81 ± 0.17 mm (72 larvae).

Duration of fourth stadium of larvae maturing in five stadia: 4.9 ± 1.0 days (21 larvae).

Duration of fifth stadium of larvae maturing in six stadia: 3.5 ± 1.0 days (41 larvae).

Ultimate-Stadium Larva. (Figs. 3–6). Extremely variable in colouring and maculation. Head varying from pale greyish-yellow, through greenish-yellow, orange-



Figs. 7, 8. *Pyrrhia exprimens* (Wlk.), apical abdominal segments of pupa. 7, Ventral; 8, right lateral.

yellow and orange to orange-brown; darker heads almost always with black arcs diverging upward and outward from centre of face and with a black band across frons and lower surface of genae. Prothoracic shield showing same colour variation as head, commonly-marked with black spots or patches near anterior and posterior margins. Suranal shield usually blending with colouring and maculation of trunk. Rims of spiracles light brown. Setal bases varying from black to concolorous with trunk; paler setal bases usually each with a dark apical ring. Thoracic legs and proleg shields varying from black to concolorous with suprapodal area.

Trunk white, yellow, or green variably marked with black; yellow larvae often so heavily marked with black as to appear predominantly black.

Yellow and black colour phase: Middorsal band black with an irregular and discontinuous, white or yellow, median line. Subdorsal area yellow and white with two irregular and discontinuous, black median lines. Supraspiracular area dull black variably and irregularly marked with pale olive-green and white. Spiracular band white dorsally, pale yellow ventrally. Suprapodal area pale olive-green, variably and irregularly marked with dull black. Midventral area pale olive-green.

Yellow colour phase: Middorsal band greyish- or brownish-yellow weakly marked with black. Subdorsal area paler, clear yellow, with a pair of vaguely expressed black median lines. Supraspiracular area brownish- or greyish-yellow; irregularly marked with dark brown, particularly along margins. Spiracular band clear light yellow, margined dorsally with white. Suprapodal area greyish-yellow, lightly and irregularly marked with clear, light yellow. Midventral area somewhat paler than suprapodal area.

Green colour phase: Middorsal band apple-green. Subdorsal area creamy-white, irregularly marked in middle of each segment with pale green. Supraspiracular area green, irregularly and variably marked with creamy-white. Spiracular band creamy-white. Suprapodal area green, lightly and irregularly marked with white. Midventral area greyish-green.

White colour phase: Middorsal band black, discontinuous, often almost completely suppressed. Subdorsal area dead white with a pair of variably expressed median black lines; a prominent orange blotch in middle of each segment and extending into middorsal area. Supraspiracular area black, variably and irregularly mottled with white; black of supraspiracular area often suppressed on at least some segments. Spiracular band orange, often irregularly defined from supraspiracular area. Suprapodal area

dark purplish-brown, variably and irregularly marked with white, usually lightly so. Midventral area dirty yellow-grey.

Various gradations between these macular forms may also be found.

Head width: 2.86 ± 0.11 mm (23 larvae).

Duration of fifth stadium of larvae maturing in five stadia: 7.8 ± 1.5 days (21 larvae).

Duration of sixth stadium of larvae maturing in six stadia: 6.4 ± 1.5 days (41 larvae).

Pupa (Figs. 7, 8). Uniform orange-brown. Spiracles on a level with general surface of cuticle or borne in very shallow depressions. Anterior areas of abdominal segments 4, 5, 6, and 7 rather heavily pitted; dorsal surface of abdominal segments 1, 2, 3, and 8 moderately pitted. Proboscis terminating between apexes of wings. Cremaster consisting of two, rather short setae borne at the apex of a conical prolongation of the tenth abdominal segment.

Length to posterior margin of fourth abdominal segment: 11.5 ± 0.8 mm (14 pupae).

Acknowledgment

I appreciate the assistance of my associate, Mr. E. W. Rockburne in measuring larval structures, and in drawing the cremaster area of the pupa.

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A MELANIC ABERRATION OF *PAPILIO CRESPHONTES* (PAPILIONIDAE)

In 1964, I caught an extreme melanic specimen of *Papilio cresphontes* Cram. The specimen was taken in New Orleans during migrating season, probably in November. It is of normal size and nearly all black with small amounts of white where yellow should be. The hind wings are nearly all black. The specimen, considerably broken when caught, was sent to Dr. Alexander B. Klots at the American Museum of Natural History in February of 1970 for identification. His return letter stated that the museum has nothing like it, and that although several Society members have recorded melanism, none are as extreme as this.

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NEW OR UNUSUAL BUTTERFLY RECORDS FROM FLORIDA

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The following records have accumulated in the course of my collecting in various parts of Florida over the past several years.

Eurema daira daira Godart

Chokoloskee, Collier Co.: 22,31.XII.1967 (1♂ each, winter form); 19, 20.XI.1969 (4♂ 2♀, winter form; 2♂, summer form).

This widespread, common Florida species is of no particular concern in itself, but these records are of significance in conjunction with the next.

Eurema daira palmira Poey

Chokoloskee, Collier Co.: 22.XII.1967 (1♂ 1♀) and 31.XII.1967 (3♂ 3♀).

All the specimens are of the winter form "ebriola." This is the West Indian subspecies of *daira* and only a few specimens of it have ever been taken in Florida (Klots 1951; Kimball 1965). These specimens of *palmira* raise a question, but unfortunately do not answer it: Is *palmira* a subspecies of *daira* as currently believed, or is it a different, full species?

The possibility that *daira* and *palmira* are specifically distinct is suggested by the large number of differences between them (Table 1) and by the utter absence of intermediates among the specimens of both which I took in December 1967, all flying in the same area. This possibility is not diminished by the later (November 1969) captures of *d. daira* alone in the same place: there is no evidence whatever of *palmira* characters in any of these specimens and hence no evidence of interbreeding in the intervening time.

The conventional view, that *palmira* is only a subspecies of *daira,* is still possible. The specimens of *palmira* taken in December 1967 conceivably could all have been offspring of a single immigrant female. Absence of any evidence of hybridization in later captures could be explained by swamping, recessiveness of *palmira* traits, or both.

The present evidence seems to favor their being specifically distinct, but it is certainly not conclusive. Unless or until we learn that the two are capable of living together for several generations without loss of their identities, there is no reason to propose any change in their current status as subspecies.

A complication should be mentioned. Occasional specimens of *d. daira*

TABLE 1. Differences between *Eurema daira daira* and *Eurema daira palmira*, based on Floridian and Cuban material. Abbreviations used: up = upperside; un = underside; fw = forewing; hw = hind wing.

Character	*palmira*	*daira*
	SUMMER FORMS	
1. ♂ ♀ uphw ground color	white	yellow*
2. ♂ upfw costal ground color (mixed with gray)	usually white	yellow
3. ♂ upfw posterior bar thickness	not reaching Cu_2 (thin)	broadly reaching Cu_2 (thick)
4. ♀ upfw ground color	white	yellow
5. ♀ upfw posterior bar	absent	usually at least a trace
6. ♀ uphw terminal fuscous	thin and absent below Cu_1	thick and often reaches beyond Cu_2
7. ♂ upfw terminal fuscous	always extends beyond Cu_2 towards tornus	may extend beyond Cu_2, or there be cut off square
8. ♂ size**	small	large
	WINTER FORMS	
1. ♂ ♀ uphw ground color	white	yellow
2. ♂ upfw posterior bar	not reaching Cu_2 (thin)	broadly reaching Cu_2 (thick)
3. ♂ upfw terminal fuscous	always extends beyond Cu_2 towards tornus	cut off square at Cu_2
4. ♂ ♀ uphw apical black patch thickness	1 interspace-width (thin)	2 interspace-widths (thick)
5. ♀ upfw ground color	white with costal and apical yellow flush	yellow

* Rarely white (see text).
** 10 ♂♂ of summer *daira* (Stemper, Fla.): length of fw 16–17 mm, mean 16.5 mm; 10 ♂♂ of summer *palmira* (Nueva Gerona, Isle of Pines, Cuba): 13.5–15 mm, mean 14.6 mm. Females of each average larger but show a similar size difference; so do both sexes of the winter forms.

taken in southern Florida (*e.g.*, 2♂, Toms Harbor, Florida Keys, VIII. 1936 [collector unknown], Carnegie Museum) show white on the upperside of the hind wing, a characteristic of *palmira*. In all other respects these specimens are true *daira* and I infer therefore that this is simply an occasional dimorphic trait, perhaps limited to the warmer areas, and does not indicate any relationship with *palmira*.

Urbanus dorantes dorantes Stoll

Chokoloskee, Collier Co.: 20.XI.1969 (2♂ 1♀, all rather fresh).

This is a new species record for Florida. Kimball (1965) records a single specimen in the Cleveland Museum which bears two conflicting

labels (Miami, Oct. 11, 1916; and Tampa, June 1908), and is undoubtedly falsely labelled, as Kimball notes.

Urbanus proteus Linnaeus was ubiquitous and abundant on Chokoloskee in November 1969, and on the 19th I took a couple "for the record." While collecting there again the next day I was belatedly struck by the fact that some of the specimens seemed to lack the blue-green iridescence of the dorsal body and wing bases, and took three of these. They turned out to be *dorantes.* Although not as common as *proteus,* they were by no means rare and additional specimens could easily have been taken.

In view of the range and geographic variation of *Urbanus dorantes* it is important to identify the subspecies this Florida population represents as accurately as possible. Three subspecies are relevant here:

U. d. santiago Lucas (Cuba, Isla de Pinos). Upperside of forewing with hyaline spots small: bar at cell end reduced to two spots, one or both of which may be absent; spot below Cu_2 commonly absent. Underside of hind wing with ground color dark purplish brown (except for paler terminal area), often nearly as dark as the dark transverse bands.

U. d. cramptoni Comstock (Puerto Rico, Hispaniola). Upperside of forewing with hyaline spots averaging medium-sized, but varying from as small as in some *santiago* to as large as in some *d. dorantes*: bar at cell end usually entire, rarely divided into spots and never with one or both spots absent; spot below Cu_2 occasionally absent, commonly reduced (much less than half as large as spot in M_3-Cu_1), occasionally large (half or more the size of M_3-Cu_1 spot); second spot from costa of the subapical three spots with its distal edge in line with the first or somewhat basad, only rarely a little distad. Underside of hind wing pale ashy or lavender brown, with dark purple brown bands, both sexes similar.

U. d. dorantes Stoll (Texas and Arizona south to Paraguay and Argentina). Upperside of forewing with hyaline spots large: bar at end of cell always entire; spot below Cu_2 always present, large; second spot from costa of the subapical three spots with its distal edge usually distad of the first, rarely in line. Underside of hind wing pale ashy or lavender brown with dark purple brown bands; in the female sometimes with ground much paler ashy.

The three Florida specimens are a small sample but they show these traits: upperside of forewing with hyaline spots large: bar at end of cell entire; spot below Cu_2 present, large; second spot from costa of the subapical three spots with its distal edge distad of the first in all three specimens. Underside of hind wing pale ashy or lavender brown with dark purple brown bands. The single female has the ground much paler than the males.

The Florida specimens thus agree in every respect with the mainland Central and South American subspecies, *d. dorantes.* With Kimball (*loc. cit.*) we should certainly have expected any Florida specimens of *dorantes* to be of the distinctive Cuban subspecies, *santiago.* Where, then, did this population come from? How long has it been on Chokoloskee? How did it get there? Has *dorantes* been overlooked elsewhere in Florida (or

the Gulf Coast of Louisiana and Mississippi) because of its resemblance to the common *proteus*?

Note. After the manuscript of this paper had been submitted, Dr. Lee D. Miller wrote that he had captured a female of *U. d. dorantes* at Homestead, Dade Co., Florida, on 19.III.1970. This locality is on the opposite side of the state, suggesting that *dorantes* is widespread in southern Florida. This, in turn, implies that *dorantes* may be a recent arrival or specimens surely would have been taken long before this.

Euphyes dion Edwards

3.1 miles east of Trenton, Gilchrist Co.: 30.IV and 1.V.1968 (5♂).

A new species record for Florida. These specimens represent true *dion*, not the so-called subspecies *alabamae* Lindsey, already known from Florida (Kimball 1965), which I regard as a distinct species following Clark & Clark (1951). *Euphyes dion*, however, may need to be racially divided. Southern specimens are darker below, the ochraceous distinctly maroon tinged and the fulvous above reduced in extent.

The above specimens were found at *Pontederia* flowers in a water-filled roadside ditch, as is discussed more fully under the next species.

Poanes aaroni howardi Skinner

3.1 miles east of Trenton, Gilchrist Co.: 29.IV, 30.IV, 1.V.1968 (13♂ 3♀).

Records of this species in Kimball (1965) are few and mostly confined to the autumn. Other localities in Carnegie Museum are: Okeechobee [Okeechobee Co.], Fla.; Royal Palm State Park [which one?], Fla.; and a series taken in late June–early July in the northeastern corner of Monroe Co., Fla.: all *leg.* W. R. Sweadner.

In view of the temporal dissociation of certain Pennsylvania hesperiines to avoid competition for flowers (Clench 1967), the association observed in Gilchrist Co. deserves special comment. The locality lies 3.1 miles east of Trenton, on Florida Highway 26, and consists of long water-filled ditches on both sides of the road. The surrounding area is a patchwork of open marsh, wet meadows (sometimes dry, sometimes inundated), grassy and sedgy pine–cypress swamp, and dry pinelands. At the time *aaroni* and *dion* were collected the area was in the throes of a drought that had lasted several months, yet there was still an abundance of water locally.

I have paid a number of visits to this locality. Three of them were in late April and early May (29.IV, 30.IV, 1.V.1968). At this time I found the following Hesperiinae, all fresh, frequenting the roadside ditches and the *Pontederia* flowers in them: *Atrytone logan* Edwards (the commonest, 19 taken); *Poanes aaroni howardi* Skinner (nearly as common, 16 taken); *Ancyloxipha numitor* Fabricius (6 taken); *Euphyes dion* Edwards

(5 taken), *Wallengrenia otho* Abbot & Smith (3 taken). A few additional hesperiine species were also taken, but as single specimens only.

Of these, *aaroni*, *logan*, and *dion* in particular were feeding at the blue flowers of *Pontederia*, which grew abundantly in the ditches, and on nothing else. A few other plants were in flower and I repeatedly checked them, always with negative results.

About five weeks later, on 8 June 1968, I visited the area again. The *Pontederia* flowers were almost completely gone and not one of the hesperiines was found. Two subsequent visits were made in 1969: one on 19 March, the *Pontederia* barely emergent above the deep water in the ditches and not yet in flower; and one on 24 November, when the ditches were nearly dry, overgrown with grasses, mostly dead, and no *Pontederia* flowers at all. Neither of these visits yielded any of the hesperiines.

These three skippers, *logan*, *aaroni*, and *dion*, may be single brooded locally, all flying synchronously for a few weeks in the spring, although the possibility of a second brood in summer or fall in this area is not yet excluded. The significant point in the present connection is that although they are competitors these skippers apparently are forced to fly contemporaneously by the brief flowering time of their only source of adult food, *Pontederia*.

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PIERIS PROTODICE AND *URBANUS DORANTES* IN SOUTHERN FLORIDA

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Collecting in Florida has uncovered many butterfly and moth species known from nowhere else in the United States, yet, paradoxically, many species which logically should be well known from there appear to be rare or absent. New records from the state are being reported every

year. The implication is clear: Florida's lepidopteran fauna is still poorly known, despite all that has been written on it. The observations on the two species below, taken in Dade and Monroe counties during late March and early April, 1970, serve to demonstrate this fact rather graphically.

Pieris protodice protodice Boisduval and LeConte

Kimball (1965, p. 37) says about this butterfly, "At present this species seems to be very rare in Florida." The majority of his records are from the northern part of the state, and the species is reported more and more rarely as one proceeds southward along the peninsula. On the east coast the most southerly records are from Fort Lauderdale, Broward County, and Paradise Key, Dade County, where the butterfly is listed as rare. We found a thriving colony of this species in a grove at the north end of Homestead, Dade County, and took a number of specimens from 19 March through 3 April. Because fresh specimens were seen throughout this period, we feel that the butterfly probably has a long flight period at Homestead. Had one been concentrating on *protodice* it would have taken little time and effort to collect fifty or more specimens in a day, so this butterfly cannot be considered rare there. One of the foodplants, Shepherd's Purse, *Capsella Bursa-pastoris,* a common weed in the north, was also abundant in the grove, so the checkered white was not lacking for larval food. Perhaps the recent lowering of the southern Florida water table has provided a more hospitable environment for *Capsella* in disturbed habitats, and *protodice* may be spreading southward with the success of its foodplant.

Urbanus dorantes dorantes (Stoll)

Clench (1970) has recorded this species from Chokoloskee, Collier County, and has listed the first of our specimens from the north end of Homestead, Dade County. Subsequently we collected eight more specimens from the same area between 30 March and 3 April and saw many others that were not taken. Two additional specimens were taken along a trail through a small hammock on Key Largo, 17 miles northeast of Tavernier, Monroe County, on 31 March. Two others were seen, but not captured, in the same locality on 4 April. The Key Largo specimens were taken in the company of such typical hammock species as *Eunica tatila tatilista* Kaye and *Phocides pigmalion okeechobee* Worthington.

Neither Clench (1970) nor we know to which subspecies the purported Florida *dorantes* in the Cleveland Museum belongs (Kimball, 1965: 51), and we doubt the validity of the specimen in any case. We are in full

agreement, however, that the recent specimens are nominate *dorantes* (for a discussion of the differences see Clench, 1970), which otherwise is found from Texas and Arizona southward on the continent, rather than either of the Antillean subspecies. Just how the continental subspecies, with an apparent disjunction in range of about a thousand miles by land and several hundred miles over water, comes to be the Florida subspecies in preference to the Cuban subspecies, *d. santiago* (Lucas), with only a ninety-mile water barrier to cross, is indeed a zoogeographic puzzle. Postulation of a colonizing flight from Mexico or Texas across the Gulf of Mexico being successful when no colonization in the same manner from Cuba has taken place seems beyond the limits of credibility. There also could be a narrow strip around the Gulf of Mexico from Texas to Florida in which the species occurs, but if this is true, why have intervening populations not been found? Even in the area from Tampa to Fort Myers, Florida, where some of the most comprehensive collecting in the state has been done in recent years by Kimball, King and others, *dorantes* has not been detected, so it seems that the idea of interconnected populations from Florida to Texas is unlikely. The remaining idea, that *dorantes* was introduced artificially, seems most reasonable. Certainly once it got into southern Florida it should thrive, because there is no shortage of Fabaceae to serve as larval food in the area, and the climate is comparable with that of other places where this species is native. *U. dorantes* must be a relatively recent arrival in the Homestead–Key Largo area, since it was not recorded by the industrious collecting over many years by Mrs. Leslie E. Forsyth of nearby Florida City.

Most of the specimens we took were in shaded parts of the two habitats, rather than in bright sunlight, and the butterflies were most commonly found during the hottest part of the day. Their habits rather closely resembled those of the Baja California, Mexico, populations (Miller, in press) in that they fluttered around the shaded parts of the area and tended to shun the open places when the sun was brightest. In such shaded areas *dorantes* was by far the dominant *Urbanus,* but in sunny places *U. proteus* (Linné) was commonest. The butterflies are avid flower visitors, preferring blooms of *Bidens,* so long as these blossoms are in comparative shade. Specimens will take up perches and chase other butterflies in their "territories." *U. dorantes* is rather more wary than *proteus,* except when they are at flowers.

We would like to thank A. C. Allyn and Miss D. Dunklau for help in collecting material and H. K. Clench and C. P. Kimball for comments and suggestions which led to this paper.

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A NEW SPECIES OF *PIRUNA* FROM TEXAS (HESPERIIDAE)

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During the summer of 1968 J. E. Hafernik collected rather extensively in the Big Bend area of Texas. Among the many very interesting species that he collected were two specimens of an undescribed species of *Piruna* that is here described.

Piruna haferniki Freeman, **new species**

MALE (Upper side): Primary dark brownish-black, with seven white, hyaline spots; a prominent, oval, spot in space 2 and midway between this spot and base of wing another much smaller spot in same space. In space 3, a small, round, spot situated directly under apical spot in space 6. Three well developed apical spots of approximately same size in spaces 6, 7, and 8, forming a straight line; lower spot directed toward an area between apex and mid termen of wing. A small, upper cell spot. Fringe light brown, uncheckered.

Secondary dark brownish-black, unmarked. Fringe light brown, uncheckered.

MALE (Under side): Primary brown, slightly lighter in the apical region. White, hyaline spots present and better defined than on upper side.

Secondary dark brown with a heavy overscaling of purplish-gray scales over basal half of wing and extending from anal fold along outer margin to space 5. A slightly ferruginous area extending above space 5 along outer margin to apex. Throughout discal area from space 1 to costa an area without overscaling; here brown ground color forming a broadly triangular area darker than the remainder of the wing. No spots present.

BODY: Thorax dark brownish-black above, lighter brown beneath. Abdomen dark brownish-black above, lighter brown beneath. Head brown, with a few yellowish, hair scales present. Palpi white at base, yellowish at termen, dark grayish on lateral sides. Legs golden brown. Antennae, both shaft and club, dark brownish-black above, lighter beneath; club especially pale beneath, yellowish. Apiculus golden.

Wing measurements. Primaries: base to apex, 11 mm; apex to outer angle, 7.5 mm; outer angle to base, 9 mm. Secondaries: base to end of vein 3, 9.5 mm; center of costa to anal angle, 7.5 mm. Total expanse: 23 mm.

Type Material: Holotype, male, Green Gulch, Big Bend National Park, Brewster County, Texas, elev. 5700 ft., 4 August 1968 (J. E. Hafernik) in the American Museum of Natural History, New York. One male paratype, same location and collector, 24 July 1968, at present in my collection.



Figs. 1 and 2. Upper and under side of *Piruna haferniki* Freeman, holotype, male, Green Gulch, Big Bend National Park, Brewster County, Texas, elev. 5700 ft., 4 August 1968 (J. E. Hafernik).

Superficially on the upper side *P. haferniki* resembles *P. cyclosticta* (Dyar); however the maculation is much better developed in *haferniki.* There are two basic features in *haferniki* which readily separate it from any other *Piruna*: (1) In all other species of *Piruna*, the apical spot in space 7 is either smaller than the other two or else absent, whereas in *haferniki* it is approximately the same size as the others; in all other *Piruna* the line formed by the apical spots is directed toward the center of the outer margin of the wing instead of between this area and the apex as it is in *haferniki.* (2) No other *Piruna* has the unusual purplish-gray overscaling on the under side of the secondaries leaving the darker brown discal area which is present in *haferniki.*

There are basic differences in the genitalia, especially the uncus, separating *haferniki* from the other known species of *Piruna. P. haferniki* is a member of the *brunnea* complex which contains *brunnea* (Scud.), *cyclosticta* (Dyar), and *pirus* (Edw.), and can be readily distinguished from these three species by the above characteristics.

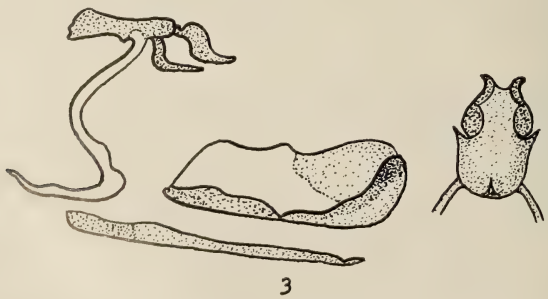


Fig. 3. *Piruna haferniki,* male genitalia of paratype, Green Gulch, 24 July 1968 (Hafernik).

Acknowledgments

The author wishes to thank the American Philosophical Society for a grant which is making research on the Hesperiidae possible. The photographs of the adults used in this article were made by Mr. William L. Skinner, Physics Teacher, Hillcrest High School, Dallas, Texas.

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OBSERVATIONS ON SOME PHYCITINAE (PYRALIDAE) OF TEXAS WITH DESCRIPTIONS OF TWO NEW SPECIES

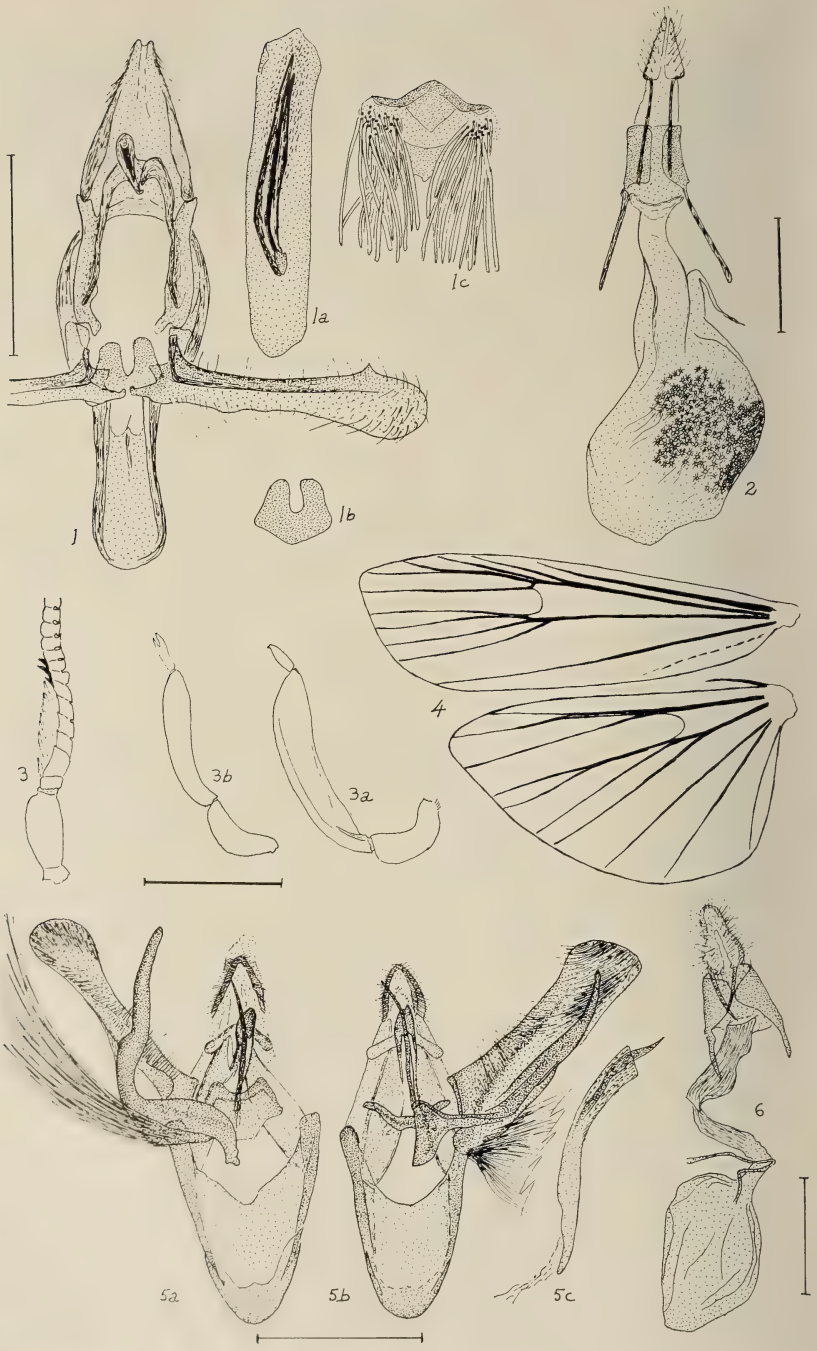
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The latest revision of the Phycitinae is that of Heinrich (1956). It includes a description and figures of genitalia of every New World species known at the time of its publication. It makes it possible, for anyone who can dissect genitalia, to identify a very large proportion of his captures and to call for expert advice in difficult cases only.

In trying to classify my Phycitinae I have been puzzled by several species which do not appear to be included in Heinrich's monograph. For all of these, except two, I have only one specimen or specimens of only one sex. These will have to wait a little longer. This paper offers a description of the two new species of which I have males and females; it also includes an annotated list of some species which Heinrich had not seen from Texas or even from the United States.

Zamagiria kendalli A. Blanchard, **new species**

Male: Tongue well developed. Antennae brown, shortly ciliate, a deep sinus at base of shaft, fringed with heavy scale tufts, bearing on each of the three upper segments a claw-like, well-sclerotized process (Fig. 3). Head slightly depressed between antennae and in upper part of front. Labial palpi recurved ascending, first segment whitish, second segment sprinkled with brown scales, very long, broadly dilated and hollowed within to hold maxillary palpi, third segment minute (Fig. 3a). Maxillary palpi in the form of large aigrettes. Head, collar and disc of thorax dark


1
1a
1b
1c
2
3
3a
3b
4
5a
5b
5c
6

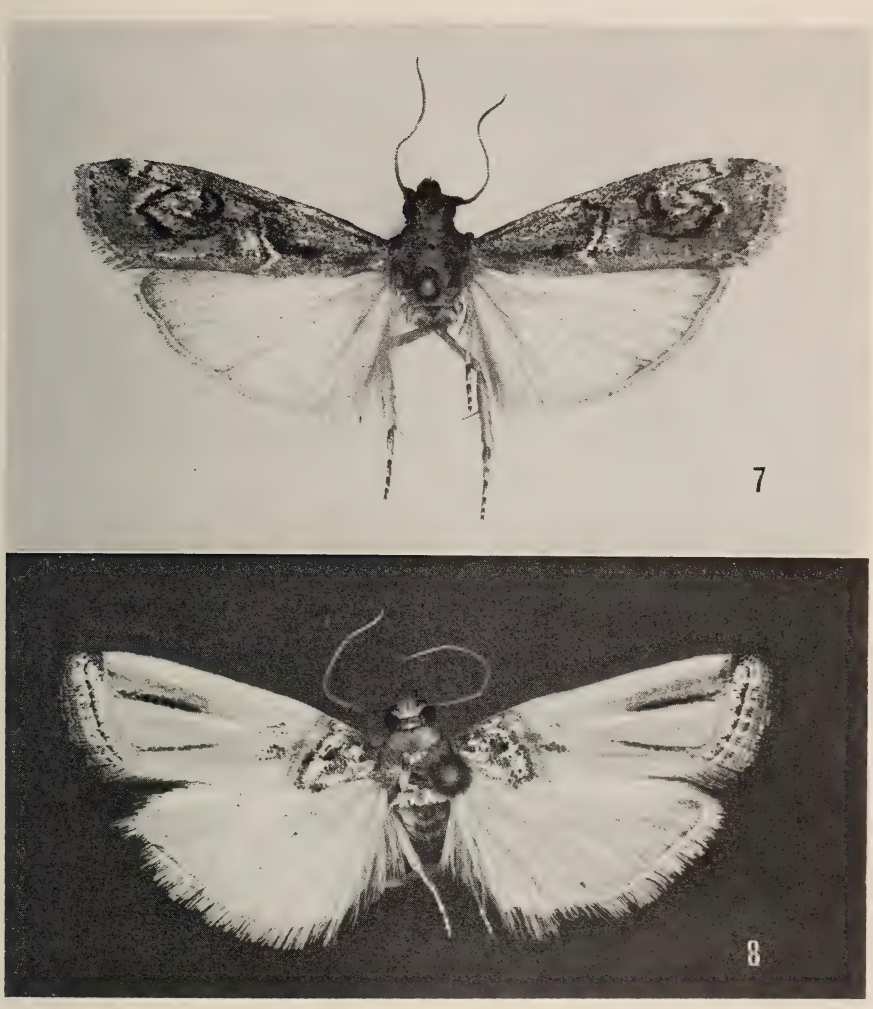


Fig. 7. *Zamagiria kendalli*, holotype.

Fig. 8. *Dasypyga salmocolor*, holotype.

←

Figs. 1 to 4. *Zamagiria kendalli*. 1, Male genitalia, aedeagus omitted; 1a, aedeagus; 1b, transtilla; 1c, tufts of eighth abdominal segment; 2, female genitalia; 3, part of male antenna; 3a, denuded male labial palp; 3b, denuded female palp; 4, venation (female wings).

Figs. 5 to 6. *Dasypyga salmocolor*. 5a, Male genitalia moderately expanded, aedeagus omitted; 5b, male genitalia fully expanded, aedeagus omitted; 5c, aedeagus; 6, female genitalia.

(Scale shown on all figures is one millimeter except for 1c and 4.)

brownish gray; patagiae darker; abdomen above lighter. Underside of thorax, abdomen and legs grayish white. *Primary* (Fig. 7) with ground color pale bluish gray, heavily dusted, mostly between radial vein and inner margin, with brownish to reddish and a few black scales. T.a. line well defined only between radial and anal veins, bluish white; narrowly bordered distally by a black line bending basad, almost squarely, over the radial and running to costa; narrowly bordered basally by a black line meeting a broader, black basal dash on anal vein. S.t. line bluish white, best defined by its black inner border deeply and sharply indented opposite upper angle of cell and on Cu2; this last cusp bringing it below discocellular vein. A crescent shaped spot, with ground colored center, entirely outlined in black at the end of cell, the more basad arc of the crescent contour lying directly over discocellular vein. Black, intervenular, almost confluent, terminal dots. Fringe light brownish gray. *Secondary* grayish white, slightly darker at apex and along termen. Fringe light gray; the shorter scales, being dark tipped, produce a median blackish line. *Undersurface* of *primary* almost uniformly brown, basal half of costa darker. *Secondary* iridescent grayish white, brown between costa and radial vein and near apex.

Female: Similar to male except for the following: antennae simple pubescent, labial palpi (Fig. 3b) not hollowed out, ascending but not exactly applied against front, maxillary palpi minute, filiform.

Venation: As shown in Fig. 4.

Expanse: 20 to 24 millimeters.

Male genitalia: As represented by Fig. 1, 1a, 1b. Uncus broadly triangulate. Gnathos elongate, arising well down from ventrolateral projections of tegumen, terminating in a spatulate, hollow hook. Transtilla absent. Aedeagus stout. Penis armed with one or two strong cornuti. Eighth abdominal segment with ventral tuft as shown in Fig. 1c.

Female genitalia: As shown in Fig. 2.

Of all the genera included in Heinrich's monograph, *Zamagiria* appears to accommodate *kendalli* best: the venation, labial and maxillary palpi, male antennae, as well as the male and female genitalia indicate a close relationship. The head, however, in the upper part of the front and between the antennae, is somewhat depressed rather than deeply grooved, and the "appressed, matted tuft of long scales arising from the upper edge of the frons" is missing. Although the male genitalia differ markedly from all those figured by Heinrich (which, as he remarks, exhibit striking, structural, specific differences among themselves) they agree quite well in general characters. The combination of elaborate wing masculation and genitalia differentiate this species very definitely from all previously described taxa.

Food plant: On 7 July 1969 in Musquiz Canyon (Tex. Hwy 118) N.W. of Alpine, Texas, Roy and Connie Kendall found several larvae, sheltered inside folded or rolled portions of leaves of *Croton fruticulosus* (Engelm.). They reared three with the following results: pupated 10 July (1), ♀ emerged 23 July; pupated 12 July (1), ♂ emerged 23 July; pupated 18 July (1), ♀ emerged 28 July.

I have these three specimens before me; as they are definitely conspecific with those taken in our light traps, they are labeled paratypes.

It gives me pleasure to name the new species for our dear friends, who have discovered the life histories of many Texas species of Lepidoptera, and with whom we have enjoyed many fruitful and pleasant field trips.

Type material: Holotype male, Fort Davis, Hospital Canyon, behind historical fort (Jeff. Davis Co.), Texas, 5000′, 11 July 1969 (genitalia on slide A.B. 2050); deposited in the U.S. National Museum (No. 71004).

Eighteen paratypes, including the three listed above in the Kendall collection: Fort Davis, 1♂, 3♀♀, 24 Aug. 1967; 1♂, 1♀, 11 June 1969; 3♂♂, 5♀♀, 11 July 1969; Guadalupe Mts., Bear Canyon, 5700′, Culberson Co., Texas, 1♂, 4 Sept. 1969.

Dasypyga salmocolor A. Blanchard, **new species**

Head covered with ochreous salmon scales, paler and thinner on front than on vertex, with a transverse parting line behind antennae. Tongue well developed. Antenna weakly pubescent. Labial palpus upcurved, not quite reaching vertex, very slightly longer in female than in male; third segment a trifle longer than second, acuminate. Maxillary palpus small, squamous. *Thorax* with collar, disc of thorax, and patagiae concolorous with vertex. Legs closely scaled, varied with bright ochreous salmon, purplish black, and whitish. *Abdomen* pale ochreous salmon; with some blackish scales on the more basad segments beneath. *Upper surface of primary* (Fig. 8) ochreous salmon. T.a. line pale purplish gray, starting on costa one fifth distance from base to apex, nearly straight to inner margin, and reaching latter one fourth distance from base to anal angle; rather wide, and narrowly bordered on both sides by sprinkling of darker scales. A small patch of black, coarse, raised scales in submedian fold on inner side of t.a. line. Basal area soiled in places with purplish scales, some of them slightly raised. On male specimens, ground color somewhat darker along outer border of t.a. line, on a width about equal to width of t.a. line itself. S.t. line absent, but along termen a border about same width and color as t.a. line, continuing in a rather wide, concolorous fringe. No discal dots. In cell M_1 a fine red line running nearly to outer dark border, and thence angling sharply to apex. A similar red line on lower fold in outer area. *Secondary* pale, shining, smoky fuscous; somewhat darker along outer margin and toward apex. Fringe very pale smoky fuscous, with a fine dark line consisting of the tips of the shortest scales. *Undersurface of primary* almost uniform ochreous. *Secondary* almost uniform paler ochreous.

Expanse: 19–20 mm.

Male genitalia: As represented by Figs. 5a, 5b, 5c. Fig. 5a showing those of the type prepared with moderate expansion; Fig. 5b showing those of another specimen fully expanded to reveal inner face of valve; 5c showing aedeagus of same specimen.

Female genitalia: As represented by Fig. 6.

Type material: Holotype male, Sierra Diablo Wildlife Management Area, 6000′, Culberson Co., Texas, 1 September 1969 (genitalia on slide A.B. 2079); deposited in the U.S. National Museum (No. 71005).

Five paratypes, all from same locality: one male, 6 June 1969; two males 8 June 1969; one male 14 July 1969; one female 1 September 1969 (genitalia on slide A.B. 2080).

Dasypyga salmocolor is extremely close to *D. alternosquamella*, Ragonot. It can be distinguished from the latter by its much reduced dark basal area, extending definitely less than a fourth, instead of almost one half, the length of the wing. The male genitalia also show the close relation between the two species, but the shape of the free arm of the sacculus is quite different.

Other Interesting Records

I will now list some Phycitinae which Heinrich did not see from Texas or in some cases even from the United States, which my wife and I have collected in our effort to prepare a catalogue of the moths of Texas.

Acrobasis kearfottella Dyar: Tennessee Colony (Anderson Co.), Conroe (Montgomery Co.), Huntsville State Park (Walker Co.), end of May. These records extend the distribution indicated by Heinrich more than five hundred miles.

Acrobasis stigmella Dyar: Tennessee Colony (Anderson Co.) end of May. An extension of range of over five hundred miles.

Bertelia grisella Barnes & McDunnough: My identification of this insect has been delayed a long time by what I think is a poor representation of the transtilla in Heinrich's Fig. 187. I have a series caught at Shafter (Presidio Co.) and a few specimens from the Guadalupe Mts. (Culberson Co.), all taken in October.

Myelopsis alatella (Hulst): Seen only once, but was abundant, at Belton Reservoir (Bell Co.), 6 April 1970. Nearest locality indicated by Heinrich: Pecos, New Mexico.

Fundella ignobilis Heinrich: I have only one female specimen. The female genitalia leave no doubt about its identity. It was caught five miles southeast of Mt. Livermore in Jeff Davis Co. This is a new record for the U.S. It was previously taken in Central America.

Anadelosemia condigna Heinrich: Shafter (Presidio Co.), Big Bend National Park, Davis Mts. (Jeff. Davis Co.), October. Described from a dozen specimens caught in the Baboquivari Mts. of Arizona.

Zamagiria australella (Hulst): Two specimens only, from Santa Ana National Wildlife Refuge and from the Welder Wildlife Foundation, both taken in mid-November. The type in the U.S. Nat. Mus. is labeled Blanco, Texas but Heinrich suspected that it might be a Florida specimen. There does not seem to be any reason for this doubt any longer.

Ancylostomia stercorea (Zeller): Brownsville (Cameron Co.), mid-October, two males.

Pima albiplagiatella occidentalis Heinrich: Fort Davis (Jeff. Davis Co.), end of March, two males, one female.

Pima granitella (Ragonot): Fort Davis (Jeff. Davis Co.). Big Bend National Park (Brewster Co.), Mt. Locke in Davis Mts., end of March; Paducah (Cottle Co.) mid-April.

Quasisalebria admixta Heinrich: This is quite common in the Sierra Diablo Wildlife Management Area and in the Guadalupe Mts. (both in Culberson Co.) in June and September. Only one female was taken in Big Bend Nat. Park in October.

Actrix nyssaecolella (Dyar): Tennessee Colony (Anderson Co.) mid-April, one female.

Actrix dissimulatrix Heinrich: Huntsville State Park (Walker Co.), May, one female.

Dioryctria auranticella (Grote): Three specimens from near the top of Mt. Locke in the Davis Mts. early July.

Patriciola semicana Heinrich: Sierra Diablo Wildlife Management Area (Culberson Co.) end of September; Davis Mts. (Jeff. Davis Co.) early October.

Anderida sonorella (Ragonot) (?): Sierra Diablo Wildlife Management Area (Culberson Co.) early June and late September; Mt. Locke, Davis Mts. (Jeff. Davis Co.) September and October; Paducah (Cottle Co.) July. All my specimens have a sprinkling of rusty red scales along the inner margin of the primaries, which is not mentioned by Heinrich; yet their genitalia, male and female, agree with his figures.

Homoeosoma impressale Hulst: Fort Davis (Jeff. Davis Co.) May. Paducah (Cottle Co.) April.

Unadilla erronella (Zeller): Brownsville (Cameron Co.) November. Big Bend Nat. Park (Brewster Co.) October. A surprising record as Heinrich had it only from Central America and the Greater Antilles. Yet the female genitalia leave little doubt about the correctness of this identification.

Rhagea packardella (Ragonot): Not uncommon from June until September in my collecting places of West Texas.

Eremberga insignis Heinrich: Not uncommon at Big Bend Nat. Park in September and October but does not seem to reach even Fort Davis. A new U.S. record.

Acknowledgment

It is a pleasure to acknowledge with warm thanks the help given me by Dr. D. C. Ferguson of the Systematic Entomology Laboratory, U.S.D.A. in examining some of my specimens and revising part of this paper.

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INCISALIA FOTIS SCHRYVERI (LYCAENIDAE): BIONOMIC NOTES AND LIFE HISTORY

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and
RAY E. STANFORD
Denver, Colorado

In the years that have elapsed since the original description of *Incisalia fotis schryveri* Cross (1937), little additional information has been gathered regarding the biology of the insect. The distributional limits have been imprecisely determined, the immature stages have remained undescribed, and only vague speculation has appeared regarding possible host plants. This paper constitutes the first description of the immature stages and a record of the host plant. The insect was studied in Wyoming (by Ferris) and in Colorado (by Stanford). In the paragraphs which follow, where regional differences exist, state names will be mentioned; otherwise descriptions pertain to the entire range of *schryveri*.

Ecology and Nature of Habitat

Incisalia fotis schryveri occurs in multiple colonies in the eastern foothills of the Front Range of the Rocky Mountains in north-central Colorado, and in the continuation of this range into south-eastern Wyoming. Its northern limits, or possible blend zones with *I. fotis mossii* (H. Edwards), have yet to be determined, but in Colorado it seems to extend no farther south than El Paso Co. Records are also available from Boulder, Clear Creek, Douglas, Gilpin, and Larimer Cos. The species probably occurs also in the northeast portion of Park Co., along the Platte River, and may be found in parts of Teller Co. In Wyoming, it is known from Albany, Carbon, and Converse Cos., and is associated with the Laramie, North Platte, and Platte River drainages. Figure 1 shows records as dots and suggested distribution as shading.

The habitat of *I. fotis schryveri* in Colorado has been characterized briefly by Eff (in Brown, 1957). The species occurs in the Transition Zone, being found in sparsely wooded, brushy foothill canyons ranging in elevation from about 5,600 to slightly over 8,000 feet. The terrain consists in general of east-facing canyons containing intermittent or permanent streams separated by steeply sloping rocky ridges. The predominant ground cover is *Cercocarpus montanus* Raf.; other characteristic vegetation includes *Juniperus scopulorum* Sarg. (south slopes), *Pseudotsuga*

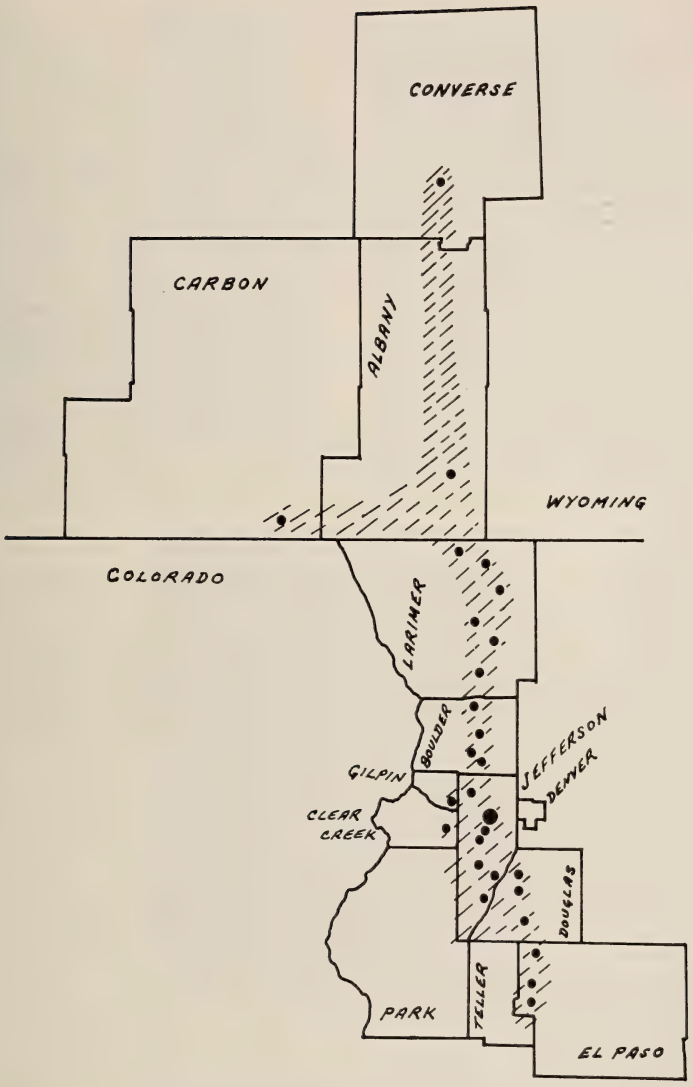
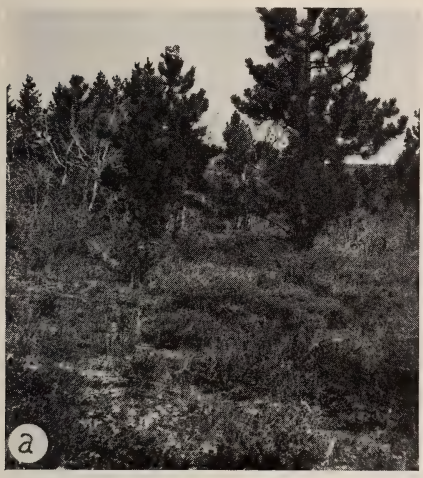


Fig. 1. Known collection areas (dots) and probable distribution (shaded areas) of *I. fotis schryveri*. **Wyoming:** Albany Co.: Pole Mtn. E. of Laramie; Carbon Co.: 20 miles S.E. of Encampment; Converse Co.: Natural Bridge. **Colorado:** Boulder Co.: Flagstaff Mtn., Boulder Canyon, Four-Mile Canyon, Gregory Canyon, Mesa Trail, Sunshine Canyon, Two-Mile Canyon, Sugarloaf, North St. Vrain Canyon; Clear Creek Co.: Clear Creek Canyon; Douglas Co.: Jarre Canyon nr. Sedalia, Platte Canyon; El Paso Co.: nr. Palmer Lake, N. Cheyenne Canyon; Gilpin Co.: Blackhawk Creek; Jefferson Co.: Chimney Gulch (type locality, large dot on map), Coal Creek, Golden, Lookout Mtn., Platte Canyon, Bear Creek Canyon, West of Morrison, Red Rocks Park, Clear Creek Canyon, Golden Gate Canyon, Indian Gulch, S.W. of Morrison, S. Platte Canyon nr. Waterton.

menziesii Franco (north slopes), *Pinus ponderosa* Laws., *Celtis occidentalis* L., *Mahonia repens* G. Don, *Ceanothus fendleri* Gray, *Ribes, Rhus, Yucca, Opuntia, Eriogonum umbellatum* Torrey, and *Chrysothamnus.* Typical riparian shrubs and trees include *Acer negundo* L., *Prunus, Crataegus,* and *Salix. Schryveri* seldom strays more than a few hundred yards out into the prairie, is distinctly uncommon in habitats dominated by *Quercus gambelii* Nuttall, and is nearly totally replaced by three other elfins (*I. polios* Cook and Watson, *I. iroides* (Boisduval), and *I. eryphon* (Boisduval)) above 8,000 feet. Of special interest is the occurrence of the stonecrop, *Sedum lanceolatum* Torrey, in the habitat, as it serves as the host plant for *schryveri.* Although widespread at higher elevations in the Rocky Mountains (where it serves as host plant for *Parnassius phoebus sayii* Edwards), stonecrop occurs in small, rather isolated clusters in the foothills. These are found mostly on well-drained east or northeast slopes with slight water seepage, and tend to be associated closely with *M. repens, Orobanche ludoviciana* Gray, and *E. umbellatum.* According to Eff (*in litt.*), the last of these associated plants may serve as host for *Callophrys sheridanii* (Edwards), a species sympatric and synchronic with *schryveri* in the region discussed in this paper.

Schryveri and *sheridanii* are usually the first non-hibernating species to appear in the spring, often in late March. (Artificial eclosion was effected by Stanford on 3 February 1970 by bringing pupa into a warm room.) The flight period is about three weeks, but stragglers may be found in late May or even early June. A fresh male taken by Stanford in Clear Creek Canyon, Jefferson Co., on 7 September 1968 is considered an atypical emergent rather than evidence of a second brood. The April flight period in Colorado corresponds with the blooming of *B. repens, O. ludoviciana,* and *Salix* species, but *schryveri* is seldom seen at flowers. Males tend to congregate in canyon bottoms, where they perch on various twigs or upon the ground. They exhibit markedly pugnacious behavior, chasing any other butterflies in the vicinity, and even an occasional bird. Frequently a specimen of *Nymphalis antiopa* (L.) or of *Polygonia zephyrus* (Edwards), both common species in the habitat, will be assaulted by dozens of *schryveri* simultaneously. Occasional females are seen in the canyon bottoms, nearly always fresh and either virgin or *in copula,* but to find them in numbers one must ascend the steep hillsides to the slopes where *Sedum lanceolatum* occurs. Here the females are abundant, especially in the early afternoon. They fly close to the ground and alight frequently upon stones or plants of many kinds. Oviposition has been observed only upon *Sedum,* where a female will deposit a single egg upon the superior surface of a basal leaf. Of nearly fifty eggs re-





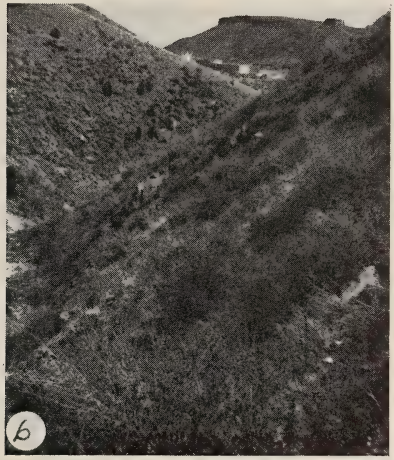


Fig. 2. a, Wyoming habitat. b, Colorado habitat. c, Host plant (*in situ*).

covered in various foothill habitats west of Denver in 1969, all but one or two were so situated. A few *Sedum* plants were found bearing two or three eggs, and an occasional egg was found on the ground beneath or nearby a *Sedum* plant. Maximum concentration of eggs was observed during the last week in April, and by May 10th, only larvae were found on the plants. The early instars fed upon the leaves, both in the field and in the laboratory, but by mid-May, when the plants were in early bloom, the by-then-third or fourth instar larvae preferred the flowers and

buds to the leaves. The pink-buff color of the third and fourth instar larvae is nearly identical to the color of the unopened buds of the Colorado morph of *S. lanceolatum,* while the pale green of the early instars matches the basal leaves, an interesting example of the changing of protective coloration. (See the description of the larvae in Wyoming which follows for comparison.)

In Wyoming, this little butterfly inhabits well-drained slopes and hill crests in the Upper Transition–Lower Canadian Zones. The vegetation characteristic of the region is sagebrush (*Artemesia* species), various grasses, *Pinus flexilis* James, *Pinus ponderosa* Laws., *Juniperus scopulorum* Sarg., *Populus tremuloides* Michaux, *Arctostaphylos uva-ursi* L., *Sedum lanceolatum* Torrey, and various annual and perennial herbs. The elevation ranges from 8,000 to 8,500 feet in most of the habitats.

I. fotis schryveri makes its appearance along with *C. sheridanii* while there are still patches of snow on the ground. It is heralded by the flowering of the sagebrush buttercup (*Ranunculus glaberrimus* Hook.) and pasque flowers (*O. ludoviciana* also known as *Anemone patens* L.). In 1969, *schryveri* was first collected on May 4th with four females and six males being taken. The last specimen, a female, was taken on May 23rd. No examples of this species were seen after this date. In Wyoming, it is sympatric with *I. polios* and *I. eryphon,* although these elfins appear on the wing about midway in *schryveri*'s flight period.

The butterfly is invariably found on the slopes with eastern or southeastern exposure. It appears to be somewhat more sensitive to weather conditions than other species with which it is sympatric. Depending upon air temperature, flight begins as early as 9:00 A.M. (MST) and extends into the afternoon until the first shadows fall over its habitat. It disappears immediately if the sun becomes obscured by clouds. The males are fond of flying about and resting upon low sagebrush plants. They may also be found sunning themselves (wings folded over back) on sandy patches of soil. The females are less active and keep quite low to the ground, frequently resting upon the ground or the host plant. They are most active about noon when they may be seen ovipositing. As in Colorado, the males are prone to combat and may be seen fighting with one another, or with other species, over the tops of the sagebrush clumps. The flight of *schryveri* is quite erratic, although never more than a few feet above the ground. Males and females are found in the same location in about equal numbers (*cf.* Colorado). The species is quite local in Wyoming and the presence of the foodplant does not indicate that the insect will be found. When located, both the insect and the foodplant will generally be in high concentration.

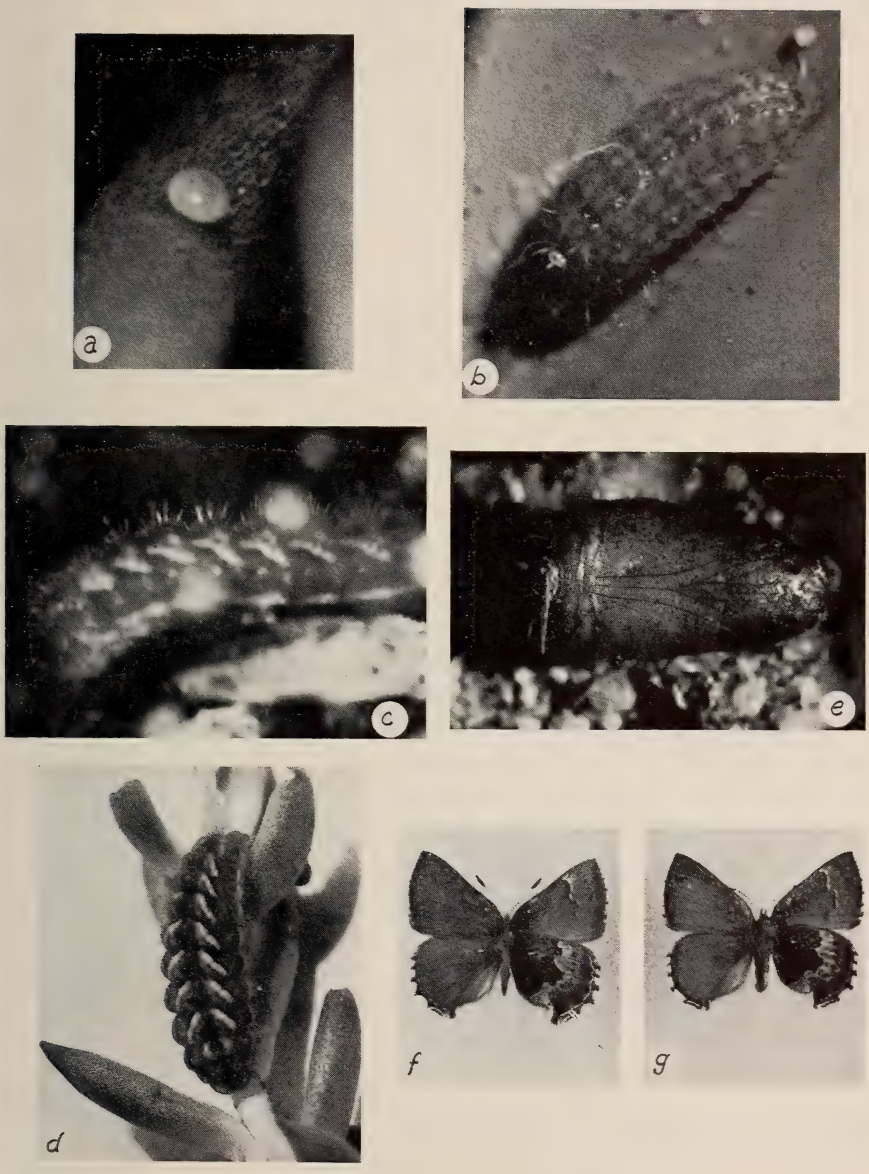


Fig. 3. a, Ovum on seedum leaf. b, Second instar larva prior to moulting. c, New third instar larva. d, Pupa, ventral aspect. e, Fourth instar larva in characteristic head down feeding position; note intensity of chevron markings. f, Adult male, dorsal and ventral surfaces. g, Adult female, dorsal and ventral surfaces.

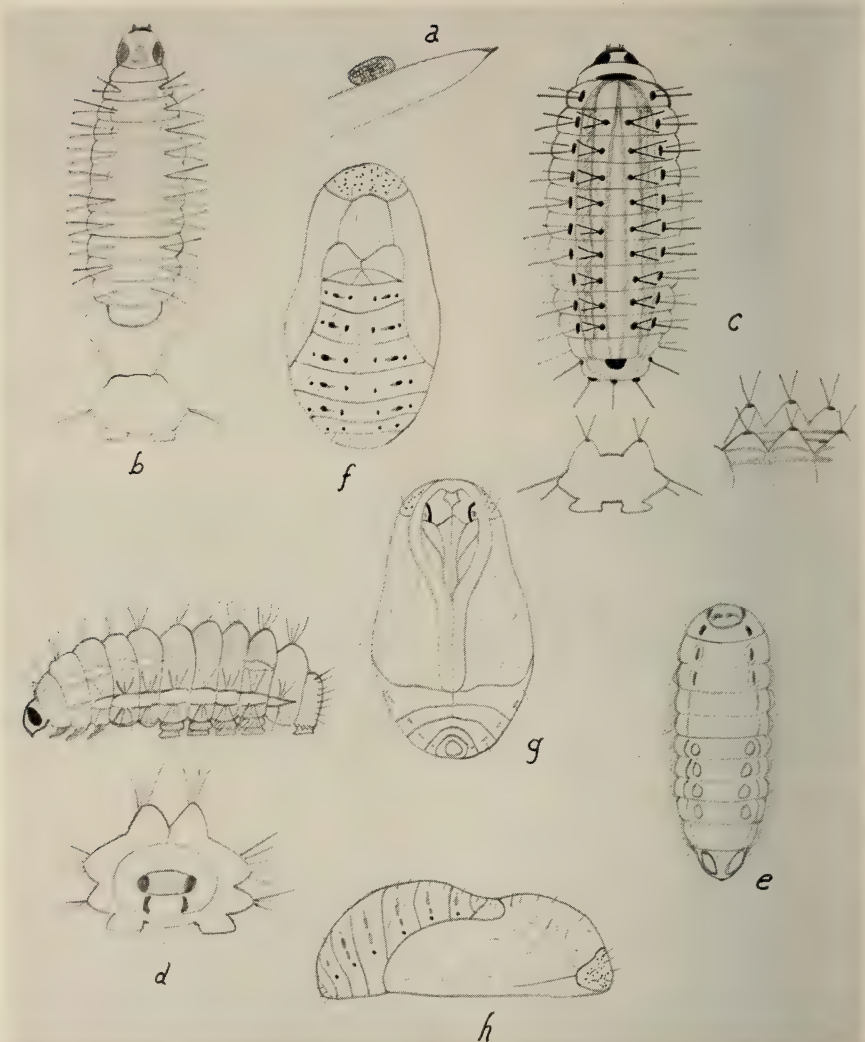


Fig. 4. a, Ovum. b, First instar, dorsal view and transverse section through a middle segment. c, Second instar, dorsal view, transverse section through a middle segment, angled view of dorsal surface of three segments showing tubercles. d, Third instar, lateral and anterior views. e, Fourth instar, ventral aspect just before pupation. f, Pupa, dorsal aspect. g, Pupa, ventral aspect. h, Pupa, lateral aspect.

The foodplant grows quite close to the ground, frequently under the clumps of sagebrush. In Wyoming, S. *lanceolatum* is distinctly polymorphic. At low elevations (7,500′), the plant is dark green with deep rose leaf tips and crown. In the Laramie Mountains in the *schryveri*

habitat, stonecrop is a yellowish gray-green with the leaf tips only faintly rose tinted and the crown yellow-green. Plants from the Sierra Madre Mountains (Carbon Co.) are distinctly rose to rust colored with yellow crowns. The flowers vary from pale yellow-green to yellow in the Laramie Mountains, and are bright yellow in the Sierra Madre Mountains.

The differences in larval feeding and adult flight patterns between the Colorado and Wyoming insects would appear to be simply adaptations to different habitats as determined by the location and morphology of the host plant.

Life Study

The description of the life stages which follows is based upon material collected in 1969 on the slopes of Pole Mountain, Sherman Range of the Laramie Mountains in Albany County, to the east of Laramie, Wyoming. This is an area in which *schryveri* has not been previously reported. The study is based upon 37 males and 32 females taken in the field. In all respects, excepting feeding habits of the larvae, as discussed previously and below, the immature stages of the Colorado and Wyoming insects are similar.

On 16 May, one egg was located on the foodplant, *S. lanceolatum*. On 17 May, a female was captured while ovipositing. On that day and the following day, three additional living females were taken. Additional eggs were secured from the habitat as well. The four females all proved to have been mated although two appeared freshly emerged. In all, about 100 eggs were obtained. The insects showed no reluctance to ovipositing in captivity. They were kept in widemouth specimen jars (screened tops) into which soil and the foodplant had been introduced.

Ovum: The eggs are oblate spheroids, pale green, about 0.8 mm in diameter. They are deposited in the natural state singly on the larger clusters with only one egg per *Sedum* cluster, which makes their location in the field somewhat tedious and time consuming. In captivity the females deposited on a single plant cluster until exhausted. In Wyoming, the one-egg-per-plant cluster in the wild state seems to be a natural protection. The larvae are extremely voracious and the foodplants are quite small in early spring. It was observed that one larva could, during its four instars, devour a single cluster of the host plant. Since, in the field, the clusters of *Sedum* may be separated by several feet, the one egg per cluster rule seems to be a guarantee of a food source to the developing larva. The eggs (in the wild) are normally deposited at the base of a leaf on the under surface (*cf.* Colorado observations). Eggs were deposited in captivity from 18 to 22 May, 1969. The eggs were maintained at an average temperature of 21° C with a plus or minus 5° C (approximately) daily variation. In the field at this time, the temperature range was from about 2° C to 24° C (air temperature) for the habitat. Twenty-four hours prior to emergence of the larvae, the eggs turn in color from pale translucent green to opaque white.

First Instar: The first larva, from the eggs of 17 May, was observed on the morning of 23 May. The first instar is illustrated in Figure 4. Initially the larva is about

1 mm long and pale yellow-green. Within 24 hours, the larva has reached 2–3 mm and the color has changed to pale tan or dark buff. The hairs are uniformly black.

Second Instar: Initially growth is quite rapid and the first larval moult of the 23 May larvae occurred on 25 May. The second instar is rose-pink and white. The pink approximates the color of the leaf buds at the top of the foodplant. Initially the larvae spend most of their time at the tops of the *Sedum* clusters. The hairs are now neutral light color. In this instar, larval length increased from 3 to 5 mm.

Third Instar: Larvae hatching on 23 May moulted into the third instar on 27 May. The basic colors were similar to those of the second instar but with a pattern change and more pink than white. The larvae have a very liquid appearance at this point. The color subsequently changes into a medium rose-pink. The light portions dorsally are very light cream while ventrally the color is a medium cream. During this instar, the length increased from 5 mm to 1 cm.

Fourth Instar: The third and fourth instars are very similar, and for this reason it was difficult to note exactly when the moult between them first occurred. It appeared to be 6 June. The last of the larvae made the transition on 13 June. The colors are somewhat muted relative to the third instar. The light areas are somewhat darker and there is an overall undertone of greenish. Just prior to pupation, the ventral areas become a dark cream color. In both the third and fourth instars, the hairs are neutral (straw) color. The larval size increased from 0.8 mm (minimum value of maximum length of third instar) to 2 cm. Prior to pupation, the larvae spin a fine light mat of silk and shrink in size to 1 cm. They assume the ovoid shape of the pupa. The prepupal stage lasts from 24 to 72 hours. During the premoult period of the last two larval stages, the caterpillars also spun light mats and remained inactive for period up to 24 hours.

Pupa: The first pupa was formed on 13 June, thus giving the period from deposition of egg to pupation as 28 days. The average length of the pupae is 0.9 cm. Initially the wing areas of the pupa are medium cream in color and the abdominal area is bright pink. Within 24 hours, the color has changed to a uniform medium brown. In captivity, the pupae were formed on the glass sides of the rearing jars, on the soil in the open, or under debris. They were loosely attached to light silk mats. The larvae exhibited a gregarious nature before pupation and clusters of from 6 to 8 pupae were common. A total of 84 pupae were obtained, the last on 4 July.

The various stages of development are illustrated in the accompanying figures.

In Colorado (material collected and observations made in April–May, 1969, Chimney Gulch (type locality) and Indian Gulch, Jefferson Co.) pupation occurred between 27 May and 8 June in the laboratory; the average duration of the egg stage was 6 days (5–8), and of the larval stage 31 days (27–35). Field observations were too few to establish the length of the larval stage in nature, but the fact that fourth instar larvae were found as late as 14 June would suggest a slightly longer maturation time in the cooler natural environment than in the 22–24° C laboratory. Pupation occurs on the ground, often several feet away from the host plant which served a given larva, and usually in a semi-sheltered spot such as near to a small stone. No pupal dissections were made to determine the stage in development when diapause takes place, but the fact that reared insects emerged from pupae within 2–4 days of their transfer from outdoors to indoors (Stanford, Denver, Colo., Feb., 1970) suggests

that imaginal development is nearly complete at diapause. Some of the Wyoming pupae showed the wing pattern of the imago within a week after pupation.

Adult: The mature insect is illustrated (Fig. 3:f,g). It is here described in detail because Cross (1937) failed to do so in his original description:

Dorsal primaries of male uniformly warm gray-brown with pad just slightly paler than ground color; dorsal primaries of female generally fulvous with apex, costal and outer margins warm gray-brown; dark color of apical area extending into subapical region. Both sexes with fringe white with some black hairs at the vein ends. Dorsal secondaries of male with basal and discal areas uniformly warm gray-brown; lower half of limbal area, extending over anal angle, and approximately one-third of lower anal margin dark fulvous; female generally fulvous over entire dorsal surface with some darker scaling in basal area and along anal margin. Fringes in both sexes same as in primaries.

Ventrally sexes similar. Primaries with apical area extending along outer margin a rich brown tending to gray-brown at the tornus. Limbally, black oval spots in cells Cu_1 to R_5 as a submarginal row. Postmedian area brown suffused with gray and white, and separated from the median portion by an irregular band which is white distally and almost black radially (basally). Discal area gray-brown tending to brown, with dark scales in basal area and with fulvous scales toward the irregular band. Secondaries with irregular band repeated. Discal and basal areas a warm brown with some gray suffusion. A submedian dark irregular band. Postmedian area gray-brown heavily suffused with white. A submarginal row of black spots, diminishing in size, one in each of cells to Cu_2. Remainder of limbal area brown irrorate with lighter scales basally and darker scales distally. A thin white band along the outer margin followed distally by a brown band showing enlargement along vein ends. Fringes as in dorsal aspect.

Head, crown, and front with dark gray-brown scaling in male and red-brown scaling in female; eyes black, hairy, bordered (ringed) with white. Thorax and abdomen concolorous with dorsal wing surfaces, and hairy. Underside of abdomen heavily overlaid with white hairs. Legs, dark gray-brown shot with white.

Wingspan of specimens in authors' collection: males and females (LFW) 1.3–1.4 cm.

The specimens from Colorado are not significantly different from those taken in Wyoming. In the Colorado material, the fulvous color of the limbal area of the secondaries is less pronounced and the general appearance of the underside is of a cooler tone of brown, that is, gray-brown rather than a warm brown. These variations are not considered as significant.

Acknowledgments

The authors would like to thank Dr. John Reeder, Curator, Rocky Mountain Herbarium, University of Wyoming for making the determination of the host plant. Dennis R. Groothuis supplied the Converse Co., Wyoming collection records for *schryveri*. Additional Wyoming records were taken from De Foliart (1956). M. Fisher and J. D. Eff provided records and field assistance for the Colorado study. Thanks are also due

John Emmel for making comments on this paper. It should be noted that he has successfully reared *schryveri* larvae on *Sedum spathulifolium* Hook., from eggs sent by Stanford and Eff. The botanical nomenclature used herein is based on Porter (1964, 1968) and Craighead (1963).

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LEREMA ANCILLARIS (HESPERIIDAE) NEW TO TEXAS AND THE UNITED STATES

In an earlier paper (1970, Lepid. Soc. 24: 59), the author briefly described the effects of hurricane "Beulah" in 1967 on the Lepidoptera populations of extreme south Texas, and the discovery of three Lycaenidae new to the U.S. A new skipper record is now given, believed also to be associated with that hurricane:

Lerema ancillaris liris Evans, 1955. A catalogue of the American Hesperiidae indicating the classification and nomenclature adopted in the British Museum (Natural History). Part IV. Hesperiinae and Megathyminae. London. British Museum. 499 pp., pls. 54–88. (Describes new sub-species of Hesperiidae. Type locality, Atoyac & Veracruz, Mexico. Type in B.M.).

One ♂, good condition, Santa Ana National Wildlife Refuge, near Alamo, Hidalgo Co., Texas, 28 September 1968 (*leg.* R.O.K.; *det.* H. A. Freeman).

Evans described *liris* from 21 specimens collected in Mexico, Guatemala, Roatan Island, Honduras, Nicaragua, and Costa Rica. H. A. Freeman (personal communication) advises that this species is common over much of Mexico, and is one of the most common species at Ciudad de Valles, Veracruz, and Oaxaca. Ciudad de Valles is about 300 miles south of Santa Ana National Wildlife Refuge, site of the first U.S. record.

Joseph F. Doyle, III records collecting a ♀ *Synapte salenus* Mabille, 27 August 1968 at the Santa Ana National Wildlife Refuge. No doubt the appearance of this insect north of the Rio Grande was also associated with hurricane "Beulah."

As with the Mexican Lycaenidae which were apparently displaced by "Beulah," it will be interesting to learn whether or not these Hesperiidae become established in extreme south Texas. There are no other known records from the United States for any of these species; however, other like specimens must have been present at the time (1968). Should any of these become resident north of the Rio Grande, the significance of great weather disturbances on insect dispersal will have been established.

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A NEW SPHINX MOTH FROM THE WEST INDIES (SPHINGIDAE)

MRS. C. REED CARY[1]

Several years ago the late Mrs. C. Reed Cary prepared a manuscript in which the following, interesting new sphinx moth was described. The publication of her paper was withheld pending the completion of more extensive works, dealing with the Macrolepidoptera of the West Indies, to which it was hoped this description could be appended. Because the appearance of the larger papers will be delayed I take this opportunity to present the following for the late Mrs. Cary.

Some editing of Mrs. Cary's paper has been undertaken and drawings have been prepared by Mr. Andre del Campo Pizzini, staff artist of the Smithsonian Institution.

J. F. G. Clarke
U.S. National Museum

In April, 1956, J. F. Gates Clarke, while a member of the Smithsonian—Bredin Caribbean Expedition, collected five specimens of the genus *Cautethia* at light on the small, isolated, and sparsely settled island of Barbuda, in the Lesser Antilles. In 1958, while on another Smithsonian—Bredin expedition he collected eight more of this moth on Antigua. The 13 specimens collected by Clarke differ so sharply from known forms that I describe them as follows:

Cautethia noctuiformis bredini Cary, **new subspecies**

(Figures 2, 4–4a)

Alar expanse 28–34 mm.

Labial palpus white basally, suffused and irrorate grayish toward apex, the second segment with large grayish fuscous blotch on outer side. Antenna gray; bases of scales somewhat darker and tips of scales narrowly edged with sordid white. Head gray, suffused fuscous; tips of scales white. Thorax gray, collar narrowly edged with grayish fuscous; tegula with broad grayish-fuscous, longitudinal stripe. Forewing ground color gray, antemedial line strongly outwardly curved, double, blackish fuscous; postmedial line double, grayish fuscous; inner element outwardly curved to vein 5 then nearly straight to outer dorsum; outer element very strongly dentate to vein 2 then broadened to tornus; terminal line very narrowly dark gray; on apical third of costa a dark gray triangle, its base on costa, extends one-third distance across wing; cilia mixed gray and sordid white. Hind wing basal half mikado orange, terminal half grayish fuscous; cilia mixed grayish fuscous and sordid white. Legs sordid white speckled and suffused with grayish fuscous; tarsi marked with grayish fuscous. Abdomen gray dorsally, buff ventrally; fifth segment with grayish-fuscous blotch laterally.

Male genitalia (slides Cary No. 76; JFGC. No. 12080). Harpe broadest basally, gently tapered to a narrowly rounded cucullus; sacculus moderately sclerotized, terminating in a cupped process set with small teeth. Gnathos stout, enlarged distally and divided postero-distally into two blunt, short, heavily sclerotized protuberances. Uncus very stout terminating in a heavily sclerotized blunt point. Vinculum very

[1] Deceased



Figure 1. *Cautethia noctuiformis noctuiformis* (Walker)
Figure 2. *Cautethia noctuiformis bredini*, new subspecies

narrow; saccus produced as a linguiform process. Tegumen broad basally, narrowed posteriorly. Anellus a broad band, narrowed laterally. Aedeagus longer than harpe, slightly curved, dorso-apically produced as sharp point; vesica armed with two small clusters of slender cornuti.

Holotype: U. S. National Museum No. 70895.

Type locality: British West Indies, Antigua, English Harbor.

Distribution: Antigua, Barbuda.

Described from the holotype (IV. 1958, J. F. G. Clarke), and 11 ♂ paratypes from Antigua with same data as holotype, and Barbuda, Oyster Pond (6. IV. 1956, J. F. G. Clarke).

Unfortunately, no females of *bredini* were collected so only the male genitalia can be illustrated for comparison.

In superficial appearance *Cautethia noctuiformis noctuiformis* (Walker) and *C. grotei grotei* Edwards are similar species, but they are easily differentiated by their genitalia (see Figures 3 and 4). *C. n. bredini* clearly belongs with *n. noctuiformis* but can be distinguished from the typical subspecies by its paler ground color and the more contrasting transverse markings. The transverse markings of *bredini* are sharply defined (Figure 2) and the preapical dark gray triangle stands out in contrast to the light gray of the forewing. On the other hand *noctiuformis* is strongly suffused with very dark gray, the transverse markings are obscured and the preapical triangle fuses with the dark coloring (Figure 1).

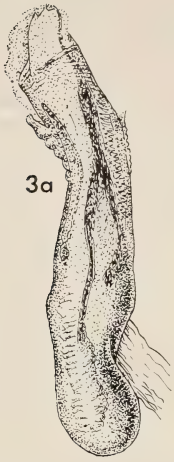
Our knowledge of the distribution of *grotei* and *noctuiformis* is too fragmentary to permit generalizations, but for the time being we can state that *grotei* (and its subspecies) is the dominant species in Cuba, Jamaica,

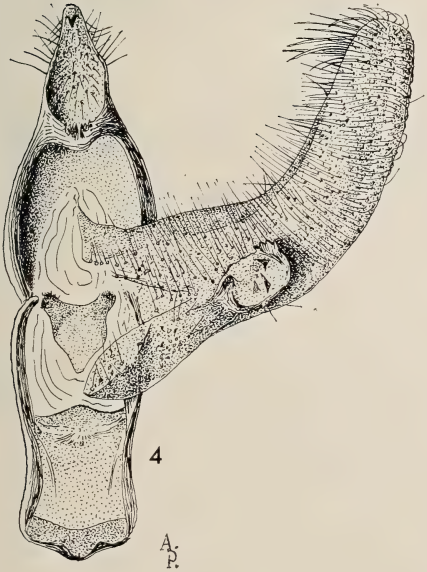
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Figure 3. *Cautethia grotei grotei* Edwards: 3, Ventral view of male genitalia with left harpe and aedeagus removed; 3a, aedeagus.

Figure 4. *Cautethia noctuiformis bredini*, new subspecies: 4, Ventral view of male genitalia with left harpe and aedeagus removed; 4a, aedeagus.


3


3a


4
A.
P.


4a

Cayman Islands and Hispaniola, and *noctuiformis* is dominant on Puerto Rico, Virgin Islands, and a few of the Lesser Antilles.

It gives me great pleasure to name this subspecies for Mr. and Mrs. Bruce Bredin who sponsored the expedition on which the specimens were collected.

A RECORD OF A NATURALLY OCCURRING *LIMENITIS* HYBRID (NYMPHALIDAE)

A suspected hybrid between *Limenitis archippus* Cramer and *Limenitis lorquini* Boisduval was collected two miles south of the Richland Y on Amon wasteway, Benton County, Washington. On July 6, 1969, three further hybrids were caught at the junction of Amon wasteway and the Yakima River by J. C. Montgomery.



Left: *Limenitis archippus.* Centre: Suspected hybrid between *Limenitis archippus* and *L. lorquini.* Right: *Limenitis lorquini.*

The four specimens of the *Limenitis* hybrids vary in color and markings. *Limenitis archippus* and *lorquini* both fly in this locality and they are the only species of the genus *Limenitis* in the area.

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LARVAE OF *HAPLOA CLYMENE* (ARCTIIDAE) HIBERNATING ON CONCRETE BRIDGES

Larvae of the arctiid, *Haploa clymene* Brown, have been found on concrete bridges, sites used for collecting winter stoneflies from northern Illinois to Florida. The larvae, encountered on numerous occasions, were often found on the completely exposed surfaces of the pillars, railings, etc., but more commonly in cracks, between pillars, and such places. The numbers on a bridge varied from one or two up to 50 or so. Larvae collected throughout the winter appear to be in the same stage with a length of 15–20 mm. Caterpillars were found from November through March.

Subsequent observations revealed that the larvae were feeding on small willows which grow along streams in central Alabama. Feeding was seen as late as November. In early November on one stream, apparently hibernating larvae were found on large rocks upstream from the bridge. It appears that the caterpillars also migrate onto bridges to hibernate since this is similar to the rock habitat.

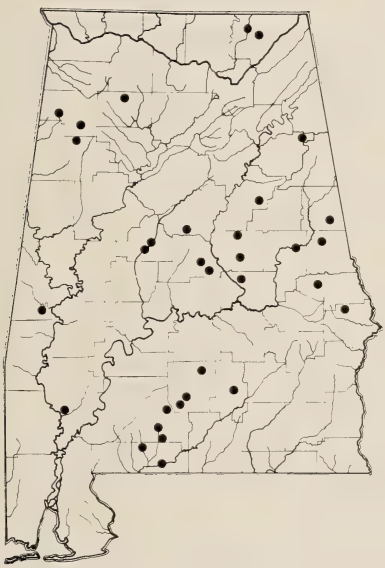


Fig. 1. Map of Alabama. Localities where larvae of *Haploa clymene* Brown were taken on concrete bridges are indicated by dots.

Hibernating larvae taken from a bridge on November 7, 1968 in central Alabama were reared on an artificial diet (Ann. Ent. Soc. America 62: 1216) in our laboratory. After one week they became active, began to eat, and molted soon thereafter. They continued to grow slowly, reaching a maximum size of about 35–40 mm. Pupation occurred on December 28, 1968, followed by emergence on March 30, 1969.

It is highly probable that such hibernation occurs in other areas within the range of *Haploa clymene*. Specific collection localities in Alabama are indicated by dots on the accompanying map. This species appears to range throughout the state. Interested persons should check their area for the "concrete bridge" caterpillar.

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CANADIAN SPECIES OF *LITHOCOLLETIS* FEEDING ON *SALIX* AND *POPULUS* (GRACILLARIIDAE)

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This paper defines the known *Salix* and *Populus* feeding species of *Lithocolletis* in Canada and the United States of America, in order that other workers may present their accumulated data on life history and ecology. The study was based mainly on material collected by officers of the Canada Forest Insect Survey and on that reared by me and my associate, Mr. G. G. Lewis. All existing types of described North American species were examined. Diagnostic characters of the male genitalia and maculation are presented. I have been unable to associate any species with *Lithocolletis salicifoliella* Clemens (1861, Proc. Ent. Soc. Philadelphia 1: 86) which was described on the basis of the larval mine. The mine is on the under surface along the edge, and usually near the base of the leaf of *Salix alba* Linn. Until adult material is obtained from near the type locality at Easton, Pennsylvania, the species cannot be recognized.

Key to Species

1. Valvae symmetrical, terminating in a downward curving, pointed apex (Figs. 9, 12). Larva mining the leaves of *Populus* spp. 2
 Valvae asymmetrical, or if symmetrical, terminating in a knob of short spines. (Figs. 14, 15). Larva mining the leaves of *Salix* spp. 6
2. Larva mining the leaves of *Populus balsamifera* L. *nipigon* sp. n.
 Larva mining the leaves of other *Populus* spp. 3
3. Thorax of adult shining ochreous or golden, with a narrow, white, median, longitudinal streak *populiella* Chamb.
 Thorax not as above 4
4. Head and thorax entirely white. Forewing predominantly white *atomariella* Zell.
 Head, thorax, and forewing not as above 5
5. Forewing with four white streaks from the trailing margin, the fourth small and near the wing apex. Wingspread 6.5–8.0 mm. *ontario* sp. n.
 Forewing with five white streaks from the trailing margin, the fifth small and near the wing apex. Wingspread 9.0–10.5 mm. *tremuloidiella* Brn.
6. Forewing with three white streaks from the trailing margin *salicivorella* Brn.
 Forewing with four white streaks from the trailing margin, the fourth small and near the wing apex 7
7. Forewing with four white streaks from the costal margin *scudderella* F. and B.
 Forewing with five white streaks from the costal margin *kenora* sp. n.

Lithocolletis atomariella Zeller

Zeller, 1875. Verh. *Zool.-bot.* Ges. Wien. 25: 350.

Maculation (Fig. 1). The following is a translation of Zeller's original description: "Thorax and head white; tuft divided into two divergent tufts, also whitish, some

of the hairs sometimes with brownish tips. Antennae white, more or less distinctly ringed. First segment of hind tarsus white, apical third brownish grey; the following three segments brownish grey with pure white bases; apical segment whitish. Abdomen dark grey with whitish anal segment."

"Width of forewing not entirely constant, but broader than in *comparella* and narrower than in *populifoliella,* without shine, pure white, with a few, black, tiny particles. The markings consisting of clay-yellow or dark ochre coloured spots which have posterior black margins. There are five on the costal margin; the first two are very oblique, sharply pointed; the first is elongated along its costal margin toward the base; the third is less oblique, and the following two, which are greatly reduced in size, are almost vertical; the last smallest one is extended in a curve to the hind margin and encloses the black apical streak. Near the base of the hind margin is a little spot which is often small or obscure, and is sometimes separated from the margin. The first dorsal spot is very oblique, sharply triangular, extending to the apex of the first costal spot, and forms with it a sharply angled broken line. The second dorsal spot, which is widely separated from the first, is longer and variable in size, and unites with the third and fourth costal spots, and since the third dorsal spot is inclined inwardly and also unites with the second, a somewhat X-like figure is formed with its apices extending to opposite margins. The black apical streak is short and margined below and apically with clay-yellow, above it the white ground colour appears as a costal spot (apically from the fifth yellow costal spot). At the base of the whitish apical fringe is a blackish curved line which reaches almost to the third dorsal spot."

"Hind wing grey with paler fringe. Underside of forewing dark grey with four indistinct costal spots which increase in size apically."

"Habitat: Cambridge, Massachusetts (Hagen) where this species is not often seen."

Male genitalia of type (Fig. 9). Symmetrical. Valva long, narrow, arcuate dorsally; apical portion obtusely angled, recurved and pointed; inner surface with numerous, short, thick spines. Uncus conical. Transtilla arched. Aedeagus tubular, weakly sclerotized. Flap of eighth sternite spatulate; apex invaginated.

Remarks. I have not seen any specimen that will match Zeller's type. No food plant was given in the original description, but because other species with this type of genitalia feed on *Populus,* I assume that is the food plant. The type is in the U.S. National Museum, Washington, D.C. The species is allied to *L. tremuloidiella* as judged from the similarity of the male genitalia.

Lithocolletis ontario Freeman, **new species**

Maculation (Fig. 2). Antenna with alternating fuscous and white bands. Face white. Tuft on vertex fuscous beneath, white above. Thorax white, mottled with black. Forewing with white and golden ochreous markings, the former speckled with fuscous and the latter narrowly margined with black apically. Four dorsal and five costal white streaks. Base of forewing white extending narrowly over the fold to the apex of the first rectangular dorsal, white streak; the first costal streak extends obliquely outward to the fold where it is narrowly connected to the second dorsal streak, situated near the middle of the wing, and narrowly extended apically to join, or almost join, the second and third costal streaks; the third dorsal streak triangular, its apex extending about half way across the wing and situated opposite the space between the third and fourth costal streaks; the fourth costal and fourth dorsal streak usually confluent and the golden ochreous markings between them and the first dorsal and second costal streaks suggesting the letter K; the fifth costal streak short and inclined inwardly; a small, black spot, bordered below with a few white scales near



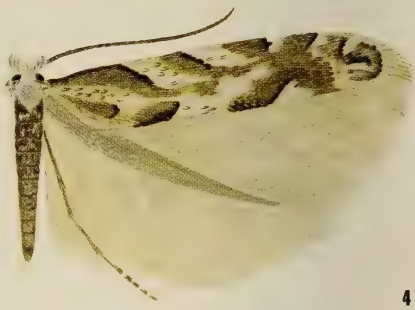
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apex; apex with a curved row of dark fuscous scales; fringe whitish. Hind wing light fuscous; fringe whitish. Wingspread: 7–8 mm.

Male genitalia (Fig. 10). Symmetrical. Valva narrow, tapering; apical portion decurved in variable degree; sparsely covered with fine spines. Vinculum V-shaped. Transtilla a semi-circular band. Uncus long, conical. Anellus thick, tubular. Aedeagus short; apex hooked. Flap of eighth sternite spatulate; apex usually invaginated.

Flight period. August and early September.

Distribution. Known only from many localities in southern and northwestern Ontario, but undoubtedly more widely distributed.

Food plants. Populus tremuloides Michx. and *P. grandidentata* Michx.

Type material. Type male, Simcoe, Ontario, 5 Sept. 1957 (Freeman & Lewis), rearing lot No. 57–174 from *Populus tremuloides* Michx. No. 10,890 in the Canadian National Collection, Ottawa, Ont. Paratypes: Nine males, six females, Simcoe, Ont., 5–11 Sept. 1957 (Freeman & Lewis), rearing lot number and host same as those of type. One male, two females, Simcoe, Ont., 9–13 May 1957 (Freeman & Lewis), rearing lot No. 57–172 from *Populus grandidentata* Michx. One male, Simcoe, Ont., 13 Sept. 1965 (Freeman & Lewis), rearing lot No. 65–83 from *Populus tremuloides.*

Mine. A blotch on the underside of the leaf.

Remarks. The maculation of this species resembles that of *Lithocolletis atomariella* Zell. but it has many more fuscous scales in the white areas of the forewing, and much finer spines on the valva of the male genitalia. The male genitalia of *ontario* resemble those of *L. tremuloidiella* Brn. (Fig. 11) but the maculation differs. There are four dorsal white streaks on the forewing of *ontario* and five on that of *tremuloidiella.* Ontario is a Huron Indian word meaning sparkling water.

Lithocolletis tremuloidiella Braun

Braun, 1908. Ent. News 19: 102.

Maculation (Figs. 3, 4). The following is Dr. Braun's original description:

"Antennae dark gray, the joints becoming lighter toward their bases. Palpi grayish white. Face grayish white. Tuft gray, mixed with white. Forewings pale reddish brown near the base, becoming more ocherous beyond the middle. There is a short median basal white streak, and a dorso-basal white streak, both thickly dusted with blackish scales, and uniting with the first dorsal streak. There are five costal and five dorsal white streaks, all dark margined internally and more or less dusted with blackish scales, the last two pair, however, not dusted. These streaks are situated as follows: a large oblique white costal streak at the basal fifth, attaining the middle of the wing and prolonged backward; nearer the base an oblique dorsal streak, almost meeting the first costal before the middle; the second costal streak also oblique; the second dorsal streak nearer the base than the second costal, large, oblique, strongly constricted just below the fold, and uniting with the apices of the first and second costal streaks; third costal and third dorsal streaks nearly opposite, less oblique, their apices separated by a narrow prolongation of the blackish internal margin. The

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Figs. 1–8. Adults of *Lithocolletis* spp. 1, Male type, *L. atomariella* Zell., Cambridge, Mass.; 2, male type, *L. ontario* sp. n., Simcoe, Ont.; 3, 4, female type and male paratype, *L. tremuloidiella* Brn., Kaslo, B.C.; 5, male type, *L. nipigon* sp. n., Fort William, Ont.; 6, male type, *L. salicivorella* Brn., Essex Park, N.J.; 7, male, *L. populiella* Chamb., Cincinnati, Ohio; 8, male type, *L. kenora* sp. n., Ramsay, Ont.

fourth costal and dorsal streaks, of which the costal is at the apical fourth, the dorsal at the tornus, form an inwardly convex white fascia. Fifth costal and dorsal streaks also form a curved white fascia. An irregular blackish apical spot. Marginal line in the cilia blackish with a bluish luster. Cilia gray. Alar expanse 9–10.5 mm. Hind wings gray. Cilia gray with a reddish tinge. Abdomen dark gray above, grayish white beneath. Anal tuft grayish ocherous. Legs dark gray, tips of the tarsi lighter."

"Described from specimens bred by Mr. W. D. Kearfott from tentiform mines on the underside of leaves of *Populus tremuloides* Michx., received from Mr. J. W. Cockle, Kaslo, B.C., Aug. 26, 1907. The imagos appeared during the same month. The mine is large (for an underside *Lithocolletis* mine), oval, and with a fine fold through its long axis"

Male genitalia of paratype (Fig. 11). Symmetrical. Valva long, narrow, arcuate dorsally; apical portion recurved, pointed, almost right angled; inner surface with several, short, thin spines. Uncus conical. Transtilla arched. Aedeagus tubular. Flap of eighth sternite spatulate.

Remarks. This species is known to me only from Dr. Braun's type and paratype in the U.S. National Museum, Washington, D.C. The species is allied to *L. ontario* as judged from the similarity of the male genitalia.

Lithocolletis nipigon Freeman, **new species**

Maculation (Fig. 5). Antenna with alternating grey and white bands. Face white. Tuft on vertex fuscous beneath, white above. Thorax mottled with black and white. Forewing with five costal and four dorsal white streaks dotted with fuscous, and with brownish-yellow markings narrowly margined with black apically as follows: one at basal quarter extending from costa obliquely outward about half way across wing; one before middle of costa extending obliquely outward about half way across wing, then angling backward as a short, oblique spur; a costal spot just beyond middle; a somewhat outwardly oblique fascia before apical region; a patch heavily margined with black apically near trailing margin, between and posterior to the first two costal markings; a larger patch from just beyond middle of trailing margin, extending obliquely outwardly to middle of wing, and often uniting with subapical fascia. Apical region pale grey with black-tipped scales sometimes united to form a black spot. Fringe pale fawn with a narrow, black, arcuate streak. Hind wing and fringe pale grey. Wingspread 8–9 mm.

Male genitalia (Fig. 12). Symmetrical. Valva long, narrow, with apical portion pointed, curved; inner surface with thin, short spines. Vinculum conical. Transtilla a semicircular band. Uncus very long, conical. Aedeagus long, tubular, weakly chitinized. Flap of eighth sternite spatulate, usually tapering; apex invaginated.

Type material. Holotype: male, Fort William, Ontario, 20 Aug. 1962. Forest Insect Survey No. S62-5112-01. No. 10,888 in the Canadian National Collection, Ottawa, Ont. Paratypes: six males, six females, Kivikoski, Ontario, 20–27 Aug. 1962; five males, three females, Fort William, Ontario, 20 Aug. 1962; one male, one female, Sioux Lookout, Ontario, 2 Aug. 1962 and 23 July 1962 respectively; one male, Ono

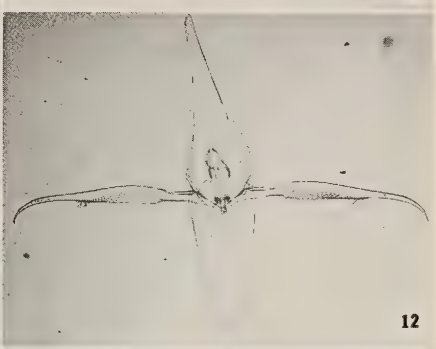
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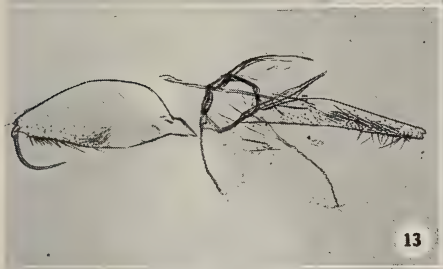
Figs. 9–16. Male genitalia of *Lithocolletis* spp. 9, Type, *L. atomariella* Zell., Cambridge, Mass.; 10, paratype, *L. ontario* sp. n., Simcoe, Ont.; 11, paratype, *L. tremuloidiella* Brn., Kaslo, B.C.; 12, paratype, *L. nipigon* sp. n., Kivikoski, Ont.; 13, type, *L. scudderella* F. & B., probably Boston, Mass.; 14, paratype *L. kenora* sp. n., Shebandowna, Ont.; 15, type, *L. salicivorella* Brn. Essex Park, N.J.; 16, *L. populiella* Chamb., Cincinnati, Ohio.


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Park, Ontario, 22 Aug. 1962. All type material reared by officers of the Forest Insect Survey, Canada Department of Fisheries and Forestry from *Populus balsamifera* L.

Distribution. Known at present only from western Ontario but undoubtedly more widely distributed.

Mine. A blotch on the underside of the leaf.

Remarks. This species has not been found on species of *Populus* other than the one above. There is only one generation each year. As judged by the male genitalia, this species belongs in the *L. atomariella* Zell. group, but *nipigon* is easily recognized by the gentle downcurved valva apex. The place name Nipigon comes from a Cree Indian word meaning the lake you cannot see the end of.

Lithocolletis scudderella Frey and Boll

Frey and Boll, 1873. Stett. ent. Zeit. 34: 212.

Maculation. The following is a translation of Frey and Boll's original description: "Of medium size; however, several specimens are considerably smaller; rather broad-winged. The ground color of the head, thorax and forewings is a peculiar light yellowish brown. This color is similar to that of a flown specimen of *L. connexella* Z. The forewings are finely scaled. Head and palpi brownish white. Antennae brownish white, annulate with darker. The legs are brownish white, the tibiae of the first pair are striped with black. Thorax concolorous with the wings, with a median whitish line. Patagia whitish. Abdomen gray, lighter at the tip."

"The markings of the forewings are somewhat indistinct, but are characteristic because of the great accumulation of black scales in the region of the fold. They are as follows: there is a rather straight basal streak ending at one-third the wing length, where it is slightly dilated. It is margined with blackish around the apex. The first pair of streaks are placed very obliquely. Of these, the costal is the smaller and is triangular. The dorsal is of very peculiar form, in that it is strongly constricted on the fold. Both are black margined internally. Usually the extent of the black scales on the inner edge of the dorsal streak is so greatly increased as to form a considerable sized black spot, which extends to the apex of the basal streak. (Less frequently these black scales are almost lacking). The next pair of streaks are at the middle of the wing length, and are also inwardly black margined. (These black scales are also increased so as to form a spot). The costal streak is narrow, almost perpendicular; the dorsal forms a broader triangle, placed just before the tornus. Toward the apex are two very narrow, slightly curved streaks. At the apex is a black dot or a streak bordered with white scales toward the base. Cilia light, darker toward the tornus, with a blackish marginal line around the apex."

"Hind wings dark gray. Cilia somewhat lighter."

"The last three light costal streaks are visible on the dark brownish underside of the forewings."

"The larvae are abundant in October and November on several species of *Salix*. The *mine* is on the underside between the veins. It is elongate-oval and somewhat wrinkled. The imagoes emerged in April and May."

Male genitalia of type (Fig. 13). Asymmetrical. Right valva elongate, slightly tapering; apex notched; a recurved, subapical, ventral spine. Left valva broad, subovate; apex with stout, recurved, ventral spine. Uncus broad, subovate. Flap of eighth sternite broad, spatulate (damaged).

Remarks. This species is known to me only from the original description, and the male genitalia of the type, that apparently was collected near Boston, Mass. The type is in the British Museum (Natural History),

London, England. As judged from the male genitalia, the species is allied to *L. salicivorella* Brn.

Lithocolletis salicivorella Braun

Braun, 1908. Ent. News 19: 101.

Maculation (Fig. 6). Dr. Braun's type in the United States National Museum is somewhat faded. I therefore quote her original description:

"Antennae pale grayish ocherous, faintly annulate with darker, somewhat darker at the tip. Palpi shining white. Face white. Tuft pale gray with an ocherous tinge. Thorax and basal third of the forewings ocherous gray. Wings becoming more ocherous towards the apex. A white band across the anterior margin of the thorax extends across the patagia and is continuous with a median basal white streak on the forewings. There is a short dorso-basal white streak, somewhat dilated posteriorly. The median basal streak is curved downwards, and extends for two-fifths of the wing length, where it is confluent with the first dorsal streak, its upper edge uniting with the apex of the first dorsal streak. A few dark brown scales extend around the apex of the angle thus formed. There are four costal and three dorsal white streaks. The first dorsal streak at the basal fourth is very large, oblique and curved. Internally, it is dark margined just before it unites with the basal streak, the dark margin being continued around the angle and for a short distance along the lower side of the basal streak. The extreme edge of the costa is dark brown for about one-third of the wing length, where the dark line is deflexed, and continues as the dark margin of the first costal streak which is narrow, very oblique, its apex extending to a point just beyond the apex of the first dorsal. The second costal streak is large, nearly perpendicular, its apex opposite to that of the second dorsal streak, which is also very large, and placed slightly nearer the base than the corresponding costal streak, and is somewhat oblique. The next pair of streaks, of which the dorsal is placed just above the tornus, are nearly opposite to each other, slightly oblique toward the base and curved; their apices nearly meet. These two pairs of streaks are margined internally with brown scales. Fourth costal streak oblique, curved and unmargined. A narrow line of black scales extends from below the apex of the last costal streak to near the apex of the wing, and is margined above by a line of white scales. Marginal line in the cilia dark brown, extending around the apex from the fourth costal streak to the third dorsal. Cilia grayish ocherous. Alar expanse 7 mm. Hindwings grayish. Cilia gray, with a fulvous tinge. Abdomen dark gray above, whitish beneath. Anal tuft grayish ocherous. Legs whitish, banded and striped with gray."

"The unique type, a male of this species, was bred by Mr. W. D. Kearfott from a much wrinkled mine on the underside of a willow leaf, collected in Essex County Park, N.J., July 6, 1902. The imago appeared July 19."

"This species is nearest to *L. scudderella* Frey & Boll, which it closely resembles in the costal and apical markings."

Male genitalia of type (Fig. 15). Asymmetrical. Right valva long, narrow, with a sub-apical, long ventral spine. Left valva sub-ovate, with a long, curved, stout, ventral spine. Uncus long, conical. Saccus U-shaped. Aedeagus tubular; apex barbed. Flap of eighth sternite broad, gradually tapering toward apex.

Distribution. Known to me only from the type locality, Essex Park, New Jersey.

Remarks. On the basis of the male genitalia, this species is allied, as Dr. Braun states, to *L. scudderella* Frey & Boll.

Lithocolletis populiella Chambers

Chambers, 1878. Bull. U.S. Geological Survey 4: 101.

Maculation (Fig. 7). Antenna, head and legs white. Thorax pale golden, with median, and two lateral, longitudinal, white streaks. Abdomen pale golden above.

Forewing pale golden with basal costal, median, and posterior white streaks, all extending to basal one-third; four costal and three dorsal white streaks dark margined basally; first costal and dorsal ones extending obliquely outward; second and third costal ones almost perpendicular, the second much smaller; second dorsal extending obliquely outward to middle of wing, triangular; third dorsal almost perpendicular to middle of wing; fourth costal near apex, large, rectangular; fringe white, with brownish basal line. Hind wing fuscous; fringe white. Wingspread 7.5–8.5 mm. Legs white.

Male genitalia (Fig. 16). Asymmetrical. Valva broad; apical portion with thick spines; left valva with curved apical spine. Uncus long, conical. Saccus U-shaped. Aedeagus tubular; apex barbed. Flap of eighth sternite subtriangular.

Distribution. Known to me only from Kentucky and Ohio.

Mine. A small tentiform underside blotch on the leaves of *Populus alba* L.

Remarks. On the basis of the male genitalia, this species belongs to the *L. atomariella* Zell. group. Chamber's type in the Museum of Comparative Zoology, Cambridge, Mass., consists of only the forewings. My description was made from specimens from Cincinnati, Ohio. According to Braun (1908, Revision of the North American species of the genus *Lithocolletis,* p. 304) "the pupa is not enclosed in a cocoon, but its anal end is attached to a small button of silk toward one end of the roof of the mine."

Chambers described this species from specimens from Kentucky and Ohio. Apparently, the only remaining specimen of his material, is one in the Museum of Comparative Zoology. This consists of both forewings glued to a pin and bears the following three labels: "type 1510"; "122"; "Kentucky." This specimen, which I have examined, I designate as lectotype.

Lithocolletis kenora Freeman, **new species**

Maculation (Fig. 8). Antenna with alternating brown and white bands. Face glossy white. Tuft on vertex white, mixed with dark brown. Thorax white, sometimes with a few, dark-brown speckles. Forewing white with glossy fawn markings, edged apically with black, and with five costal and four dorsal white streaks sometimes containing a few, scattered, blackish scales. The glossy fawn markings arranged as follows: a small, often elongate one in anal region; an outwardly oblique fascia extending from basal one-quarter of costa to middle of wing, then abruptly angled to trailing margin, sometimes with a narrow band of white separating costal and dorsal portions; another oblique fascia extending from costal half to above fold, where a somewhat anteriorly curved spur extends to a K-shaped fascia located near apical three-quarters; at apex a small patch, almost enclosing a small black dot, and with a curved spur extending to costa; apical patch markedly edged with a curved black line. Fringe whitish grey. Hind wing fuscous with lighter fringe. Wingspread 8–9 mm.

Male genitalia (Fig. 14). Symmetrical. Valva broad; dorsal region with a large patch of spines; an area of about ten scattered spines near middle of ventral margin; a spinose knob and a blunt hook on ventral margin, near apex; apical margin sometimes with a blunt tooth. Uncus long, conical. Transtilla rectangular. Saccus broadly V-shaped. Aedeagus long, tubular, with a long, chitinized supporting rod, and barbed apex. Flap of eighth sternite spatulate.

Type. Male, Ramsay, Ont., 3 Aug. 1962, No. 10,889 in the Canadian National

Collection, Ottawa. Paratypes: two males, three females, Red Lake, Ont., 15 Aug. 1962. One male, Shebandowan, Ont., 9 Aug. 1963. One male, one female, English River, Ont., 23–25 Aug. 1962. One male, Ramsay, Ont., 3 Aug. 1962. One female, Ignace, Ont., 29 Aug. 1962. One female, Finland, Ont., 17 Aug. 1962. All type material reared from *Salix* spp. by officers of the Forest Insect Survey, Canada Department of Fisheries and Forestry.

Distribution. Known only from western Ontario, but undoubtedly more widely distributed.

Mine. A blotch on the underside of the leaf.

Remarks. Clemens (1861, Proc. ent. Soc. Philadelphia 1: 81) described *Lithocolletis salicifoliella* from a mine found on *Salix alba* L. at Easton, Pennsylvania. He reared no adults but stated: "The mine is on the undersurface, usually near the base of the leaf and along the edge." Until specimens are reared from *Salix* at Easton, it is impossible to apply the name *salicifoliella* to any known species. As judged by the male genitalia, *kenora* is closely related to the *Rubus* feeding Japanese species *L. pulchra* Kumata, which possesses a median, basal, white streak. This is absent in *kenora*.

The place Kenora used to be called Rat Portage. It was changed to Kenora, a word derived from the first two letters of the following: Keewatin, Norman River and Rat Portage.

Acknowledgments

I am indebted to the following persons who have assisted me by lending types, or providing information on them: Dr. A. F. Braun, Cincinnati, Ohio; Drs. D. R. Davis and R. W. Hodges, United States National Museum, Washington, D.C.; Messrs. P. E. S. Whalley and A. Watson, British Museum (Natural History), London, England; Dr. P. J. Darlington, Jr., Museum of Comparative Zoology, Cambridge, Mass.; Mr. O. H. Lindquist and others, Forest Insect Survey, Canada Department of Fisheries and Forestry, Sault Ste. Marie, Ontario. Finally, I appreciate the assistance of Mrs. A. Mutuura, Ottawa, Ontario, who prepared most of the coloured illustrations accompanying this paper.

THE LIFE HISTORY OF *SCHINIA FLORIDA* (NOCTUIDAE)

D. F. HARDWICK
Entomology Research Institute, Canada Department of Agriculture, Ottawa, Ontario

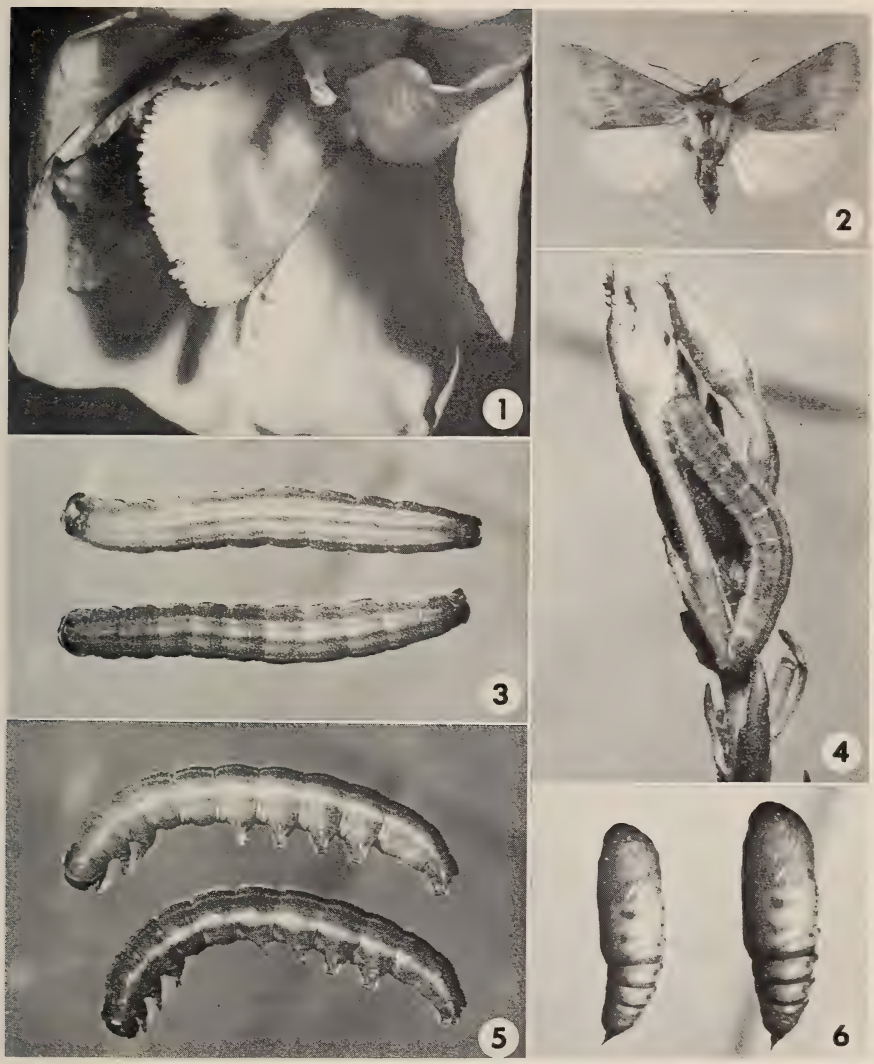
Schinia florida (Guenée 1852) feeds in the larval stage on the Evening Primrose, *Oenothera biennis* L. Previous notes on its life history have been published by Fitch (1868), Saunders (1869), Kellicott (1879), and Beutenmüller (1901), and the ultimate-stadium larva has been described by Crumb (1956).

The species is widespread in temperate North America, being distributed in southern Canada and the northern United States from the Atlantic coast to Alberta and eastern Washington. In the East, it occurs southward to North Carolina and in the West, to Colorado and Utah. It evidently does not occur in the extreme southwestern United States; the latter area is inhabited by the closely related *Schinia felicitata* (Smith), which feeds in the larval stage on the white-flowered *Oenothera deltoides* Torr. (for life history data, see Hardwick 1967).

In different parts of its range, *Schinia florida* may be found in flight between the end of May and the first of September. Because eggs are laid on the buds, the seasonal period of adult activity is co-ordinated with the blossoming period of the food plant. In the Ottawa area, the moth is usually common throughout the months of July and August. The rather protracted flight period led Forbes (1954) to suggest that the species may be at least partially double-brooded, but there is no clear evidence of this. None of the specimens reared in conjunction with the present study emerged in the same year that they pupated.

Behaviour

Schinia florida is an exclusively nocturnal species and becomes active only at dusk. During the hours of daylight, the moth rests on the flowering stalk of its food plant. Most frequently it enters the cup-shaped corolla at night and the petals actually close over the moth with the coming of daylight (Fig. 1). Usually only the yellow apical quarter of each forewing is left protruding beyond the petals, and these in their yellow colouring closely resemble the petals themselves. This behaviour pattern is not an absolute one, however; not infrequently the little moth merely nestles among the blossoms, and the pink of the basal three-quarters of the wings so closely simulate the colour of the dead but still clinging petals of *Oenothera* that even in this relatively exposed position, the moth is still difficult to detect.



Figs. 1–6. *Schinia florida* (Guenée). 1, Adult resting in blossom of *Oenothera biennis* L.; 2, adult, Alberton, P.E.I.; 3, dorsal aspect of ultimate-stadium larvae; 4, larva feeding on buds of *Oenothera biennis*; 5, left lateral aspect of ultimate-stadium larvae; 6, pupae.

The eggs are laid on the buds at the apex of the flowering shoot of the food plant; no effort is made to insert the eggs between the buds nor to conceal them beneath the petals. Five individually confined, wild-caught females deposited a mean of 114 eggs, and the maximum deposited by a single female was 198.

The newly hatched larva bores directly into one of the small buds and feeds on the sexual organs of the plant. As the larva increases in size, successive buds are attacked in a similar fashion. Larger larvae also attack the younger and more tender seed capsules by boring a hole through the wall to gain access to the developing seeds. During the later stadia, the larva does not usually secrete itself within a bud or seed capsule but feeds from an exposed position on the stem (Fig. 4); it evidently relies on its resemblance to the buds or seed capsules to protect it from predators. The skin of the larva is densely set with elongate spinules which give it a pubescent appearance similar to that of its food plant. In the last stadium, larvae exhibit two colour phases, one green and one dull red. The dull-red colour phase is evidently dependent for protection on its resemblance to dying petals or to those areas of plant tissue with a red suffusion that are characteristic of *Oenothera biennis*.

The fully grown larva tunnels into the ground to form its pupal cell, and it is in the pupal stage that the insect overwinters.

Description of Stages

The descriptions of immature stages presented here were based on the progeny of five females taken in the Ottawa area. Larvae were reared individaully at room temperature on the buds and seed capsules of *Oenothera biennis*. Rearing methods employed were those outlined by Hardwick (1958). The estimate of variability following the mean for various values is the standard deviation.

Adult (Fig. 2). Head and prothorax pink. Pterothorax pale yellow dorsally. Abdomen pallid yellow or creamy-white dorsally. Undersides of thorax and abdomen pink, or pale yellow suffused with pink. Forewing pink marked with light yellow. A quadrate yellow patch in posterior area of basal space. Remainder of basal space, median space and subterminal space light to dark pink. Median space often a paler pink than basal and subterminal spaces. A pale transverse posterior line, and darker-pink orbicular and reniform spots, often evident. Subterminal line irregular, strongly outlined by colour change between subterminal and terminal spaces. Terminal space light yellow. Fringe concolorous with, or somewhat darker than, terminal space. *Hind wing* uniform creamy white. Fringe concolorous. *Underside* of both wings pale yellow, suffused with pink along costal margins. Fringes pale yellow.

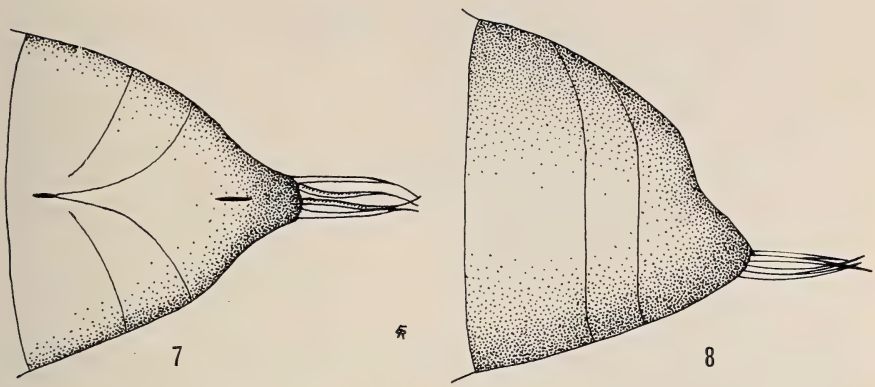
Expanse: 31.2 ± 1.6 mm (60 specimens).

Egg. Prominently ribbed on micropylar and lateral surfaces; rather deep yellow on day of deposition. A broad, subequatorial, orange girdling band becoming evident on micropylar half of egg on the day after deposition. Girdling band darkening to a dark red, and remainder of egg darkening to a yellow-orange by day of hatching. Blackish head capsule of larva becoming visible through chorion of micropylar surface a few hours before hatching.

Dimensions of egg: length, 0.651 ± 0.048 mm; diameter, 0.713 ± 0.039 mm (234 eggs).

Incubation period: 4.3 ± 0.6 days (313 eggs).

First-Stadium Larva. Head dark blackish-brown or black. Prothoracic and suranal



Figs. 7, 8. *Schinia florida* (Guenée), apical abdominal segments of pupa. 7, Ventral; 8, right lateral.

shields dark brown, somewhat paler than head. Trunk cream, yellow, or yellowish-green; a pair of subdorsal reddish-orange lines and occasionally a middorsal orange line becoming evident in older larvae. Rims of spiracles and thoracic legs dark brown.

Head width: 0.392 ± 0.009 mm (25 larvae).

Duration of stadium: 3.2 ± 0.8 days (68 larvae).

Second-Stadium Larva. Head light to medium orange-brown; in some specimens dorsal half of head mottled with darker brown. Prothoracic shield varying from yellow-fawn to orange-fawn, variably mottled with brown; shield in some specimens emarginated laterally and posteriorly with darker brown. Suranal shield straw yellow, often with a greenish suffusion. Middorsal band greenish-grey or yellowish-grey. Subdorsal area pale green or dull yellow, margined outwardly with a dark-pink line. Lateral and ventral areas of trunk varying from pale green to dull greyish-yellow. Setal bases light brown. Spiracles with medium brown rims. Thoracic legs varying from light to medium brown.

Head width: 0.614 ± 0.042 mm (25 larvae).

Duration of stadium: 2.1 ± 1.1 days (68 larvae).

Third-Stadium Larva. Head pale green, pale fawn or pale orange-yellow; dorsal half of head with faintly darker mottling. Prothoracic shield concolorous with head, often flushed laterally with dark pink. Suranal shield pale yellow or pale green. Middorsal band dull green or dull grey. Subdorsal area paler than middorsal band, pale green or straw-yellow; margined laterally by an indistinct inner greyish-white line and an outer dark-pink line. Supraspiracular area essentially concolorous with subdorsal area. Spiracular band a paler yellow or green than supraspiracular area. Suprapodal area similar in colour to supraspiracular area but with a strong greyish tone. Midventral area paler than suprapodal area. Spiracles with light brown rims. Setal bases essentially concolorous with trunk. Thoracic legs pale green or pale straw-yellow.

Head width: 0.985 ± 0.076 mm (25 larvae).

Duration of stadium: 2.3 ± 0.9 days (68 larvae).

Fourth-Stadium Larva. Head ochre or greenish-ochre, without any darker mottling. Prothoracic shield greenish-ochre, often flushed with dark pink laterally. Suranal shield light green. Trunk green, variably suffused with pink. Middorsal band narrow, dark green. Subdorsal area green, paler than middorsal band; margined laterally by an inner greyish-white line and an outer dark-pink line. Supraspiracular area concolorous with subdorsal area. Spiracular band pallid green or greenish-yellow. Suprapodal area

concolorous with subdorsal area. Midventral area light greyish-green. Spiracles with light-brown rims. Setal bases concolorous with trunk. Thoracic legs light green.

Head width: 1.65 ± 0.09 mm (25 larvae).

Duration of stadium: 3.6 ± 0.9 days (68 larvae).

Fifth-Stadium Larva (Figs. 3, 5). Occurring in a green and a dull-red colour phases, the former by far the commoner.

Green colour phase: Head pale yellowish-green. Prothoracic shield yellowish-green variably suffused with purplish-pink, often heavily so. Suranal shield light yellowish-green, essentially immaculate. Middorsal band narrow, dark green. Subdorsal area a lighter green than middorsal band, often with yellowish segmental patches; subdorsal area margined laterally by a greyish-white line and a purplish-pink band; pink band evanescing in some cases. Supraspiracular area concolorous with, or somewhat darker than, subdorsal area. Spiracular band pallid greyish-yellow, often poorly distinguished from suprapodal area. Suprapodal area essentially concolorous with supraspiracular area. Midventral area pale green with a powdery-grey suffusion. Spiracles with light-brown rims. Setal bases concolorous with trunk. Thoracic legs pale green. Green colour phase frequently with pink shading on thorax.

Red colour phase: Head orange-fawn. Prothoracic shield purplish-pink with fawn-yellow areas laterally. Middorsal band narrow, slate-grey. Subdorsal area consisting of a dorsal band of grey suffused with pink and a lateral band of purplish-pink; pink band margined outwardly by a greyish-white line. Supraspiracular area also consisting of two bands, a dorsal one of purplish-pink and a lateral one of grey suffused with pink. Spiracular band dull greyish-white. Suprapodal area dull greyish-brown. Midventral area pale grey. Spiracles with light-brown rims. Setal bases concolorous with trunk. Thoracic legs fawn.

Head width: 2.68 ± 0.12 mm (25 larvae).

Duration of feeding phase of fifth stadium: 7.1 ± 1.4 days (68 larvae).

Duration of prepupal phase of fifth stadium: 3.0 ± 1.1 days (68 larvae).

Pupa (Figs. 6, 7, 8). Dark orange-brown. Spiracles on a level with general surface of cuticle; spiracular sclerite weakly projecting. Anterior margins of abdominal segments 5, 6, 7 each with a narrow band of rather fine pitting. Cremaster consisting of four elongate setae borne on a short rounded prolongation of the tenth abdominal segment; one pair of cremaster setae borne ventral or ventro-lateral to the other pair.

Length to posterior margin of fourth abdominal segment: 9.9 ± 0.6 mm (18 pupae).

Acknowledgment

I appreciate the assistance of my associate Mr. E. W. Rockburne, in measuring larval structures and in drawing the cremaster area of the pupa.

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NEW SPECIES OF *SYLLEPIS* POEY (PYRALIDAE: PYRAUSTINAE), WITH A KEY TO KNOWN SPECIES

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Syllepis semifuneralis Munroe, **new species**

(Figs. 1, 4)

EXTERNAL CHARACTERS. Head, including palpi, antenna and basal scaling of proboscis, black; labial palpus narrowly white at base beneath; eye reticulated with brown. Antenna of male narrowly bipectinate, strongly fasciculate. Body above black. Body beneath and legs white; front leg shaded with grey dorsally. Posterior part of abdomen black.

Forewing above black. A few white scales on posterior margin basad of middle. Fringe somewhat brownish.

Hind wing above white. Base narrowly, and apex including fringe, black. A broken black subterminal line extending from apical patch nearly to anal angle. Some yellowish staining along middle of termen. Posterior part of fringe white.

Wings beneath as above, but hind wing lacking black basal patch and subterminal line, and without yellowish terminal shading.

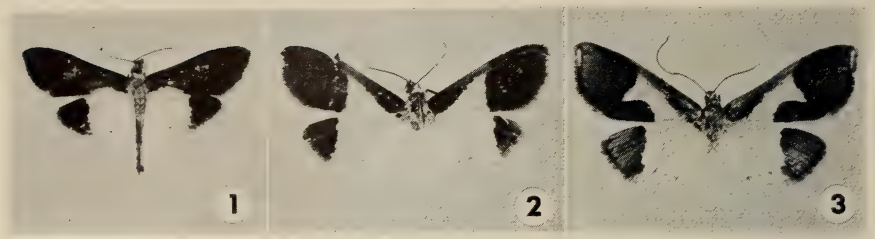
Expanse 27 mm.

MALE GENITALIA. Uncus triangular, about four times as long as basal width, narrowly rounded at apex, dorsally densely setose in distal third. Gnathos a narrow band. Subscaphium strap-like. Juxta short, roughly oval. Vinculum prolonged into a flat, blunt saccus. Valve of moderate width, somewhat expanded distally; costa narrowly inflated; sacculus moderately inflated, with a slender, dorsally directed, slightly basally curved, spine-like process from its dorsal margin at one-fourth from base to apex of valve. Penis cylindrical, weakly sclerotized, with a short, blunt cornutus.

FEMALE GENITALIA. Unknown.

TYPES. Holotype male, Bolivia: Dep. Cochabamba, Prov. Chapare, Alto Palmer, 1100 m. Type No. 11,038, Canadian National Collection. One male paratype, Peru: R. Inambari, La Oroya, 3100 ft., wet season, March 1905, G. Ockenden, in British Museum (Natural History).

REMARKS. This species resembles *S. religiosa* Munroe (1963, p. 704), but differs in having the forewing almost completely black, and in having the terminal band of the hind wing obsolete posteriorly.



Figs. 1–3. *Syllepis* spp. 1, *S. semifuneralis* n.sp., holotype, male; 2, *S. triangulifera* n.sp., holotype, female; 3, *S. latimarginalis* n.sp., holotype, female.

Syllepis triangulifera Munroe, **new species**

(Figs. 2, 5)

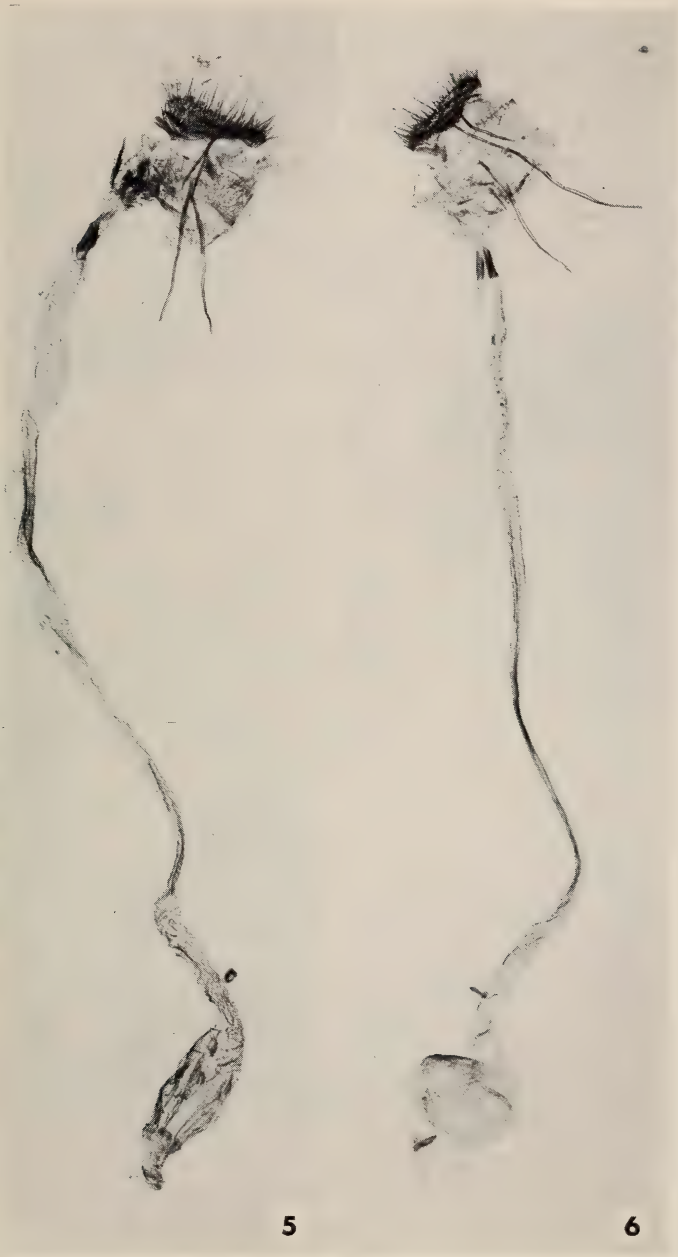
EXTERNAL CHARACTERS. Frons blackish fuscous. Vertex anteriorly fuscous with a white median patch, posteriorly fuscous. Palpi fuscous; labial palpus fuscous beneath. Basal scaling of proboscis fuscous. Eye fuscous with blackish strigae. Ocellus fuscous. Antenna of female filiform, ciliated, fuscous, dorsal scaling shading to grey distally. Body above black. Head, thorax, and basal part of abdomen beneath and legs white; front femur, tibia and tarsus infuscated; distal part of abdomen black.

Forewing above black. A broad triangular area based on posterior margin on basal half of wing white. Fringe black.

Hind wing above white. A minute black basal patch and a black triangular apical patch of moderate size. Two minute black submarginal dots near anal angle.



Fig. 4. *Syllepis semifuneralis* n.sp., male genitalia.



Figs. 5, 6. *Syllepis* spp., female genitalia. 5, S. *triangulifera* n.sp.; 6, S. *latimarginalis* n.sp.

Wings beneath as above.
Expanse 30 mm.
MALE GENITALIA. Unknown.
FEMALE GENITALIA. Ovipositor with high, narrow lobes, densely set with slender setae of varying length. Apophyses slender, nearly straight; anterior apophysis about twice as long as posterior. Ostium unarmed. Ductus bursae long, slender, membranous, very finely scobinated, and with an incomplete sclerotized collar near ostium. Bursa elliptical, finely spinulose, a little more coarsely spinulose on one side.

TYPE. Holotype, female, Peru: R. Inambari, La Oroya, 3100 ft., dry season, Sept. 1904, G. Ockenden, in British Museum (Natural History).

REMARKS. This species differs from *S. semifuneralis* in the presence of a large white area on the forewing and from *S. religiosa* in the absence of the terminal band on the posterior half of the hind wing.

Syllepis latimarginalis Munroe, **new species**

(Figs. 3, 6)

EXTERNAL CHARACTERS. Head, including palpi, eye, ocellus, basal scaling of proboscis, and basal half of antenna, black. Under side of head and base of palpus beneath white. Antenna in female annulated, ciliated; distal part brownish. Body above blackish fuscous. Body beneath and legs white. Dorsal surface of foreleg greyish fuscous. Tip of abdomen below blackish fuscous.

Forewing broad. Upper surface with costa narrowly and terminal area broadly dark chocolate brown; costa a little paler just beyond middle. An oblique white band running antero-distad from basad of middle of posterior margin, ending along and beyond anterior margin of cell, and with a broadly acute projection into terminal band behind Cu_1. A black line demarcating boundary between white medial and chocolate terminal bands, and a black line traversing terminal band from apex of projection of medial band to termen. Fringe blackish fuscous, with pale-buff scaling postapically and at tornus.

Hind wing above white. A narrow black basal patch. A large, subtriangular, chocolate-brown apical patch, with irregular black line demarcating its basal boundary. Traces of a broken black subterminal line on posterior part of wing. Anterior part of fringe chocolate-brown, posterior part white with lemon-yellow suffusion extending narrowly onto terminal area.

Wings beneath as above, but all dark areas uniformly blackish fuscous.
Expanse 30 mm.
MALE GENITALIA. Unknown.
FEMALE GENITALIA. Almost as in *S. triangulifera*, but with ovipositor lobe not so high, its long setae relatively longer and coarser; anterior apophysis about three times length of posterior; bursa with fundus rather distinctly globular.

TYPE. Holotype, female, Colombia, West Cordillera, Rio Aguacatal, 2000 m., Fassl, in British Museum (Natural History).

REMARKS. The angled outer edge of the medial band of the forewing separates this from other species with white ground colour, viz.: *S. religiosa*, *S. semifuneralis*, and *S. triangulifera.*

Key to Species of *Syllepis*

1. Fore- and hind wings above with ground colour straw yellow; distal or apical areas pink or brown 2

Hind wing at least with ground colour white; tip black or dark fuscous. Forewing similarly coloured or largely infuscated 4
2. Distal part of forewing and apex of hind wing pink *aurora* Munroe (1959, p. 359)
Distal part of forewing and apex of hind wing brown 3
3. Pectinations of male antenna shorter. Continental tropical America *hortalis* (Walker) (1859, p. 609)
Pectinations of male antenna longer. Antilles *marialis* Poey (1832, pl. 1)[1]
4. Forewing above blackish fuscous except for a narrow stripe along posterior margin *semifuneralis* n.sp.
Forewing above with an extensive white patch based on posterior margin 5
5. Distal edge of whitish patch of forewing above nearly straight 6
Distal edge of whitish patch of forewing above forming an acute angle distad behind Cu_1 *latimarginalis* n.sp.
6. Hind wing above with a blackish-fuscous apical patch, followed by one or two inconspicuous black specks or strigae *triangulifera* n.sp.
Hind wing above with a blackish-fuscous terminal band, tapering to a point at anal margin *religiosa* Munroe (1963, p. 704)

Acknowledgments

I wish to thank Messrs. P. E. S. Whalley and Michael Shaffer for the loan of material from the British Museum (Natural History). Two of the new species were first segregated by Mr. Shaffer. The photographs were made by Mr. Orrin Hanright, of the BioGraphic Unit, Scientific Information Service, Research Branch, Canada Department of Agriculture. Mr. Douglas Kritsch gave technical assistance in preparing material and illustrations.

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[1] This couplet follows Schaus (1940: 359), but the *marialis* group requires revision and will probably prove to be more complex.

NOTES ON TWO RARE MEXICAN *ADELPHA* AND RELATED CENTRAL AMERICAN SPECIES (NYMPHALIDAE)

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Members of the genus *Adelpha* usually are considered to be tropical species and usually must be sought in and around the denser moist forests. The one species that is well known outside the tropics is *A. bredowii* (Geyer) which occurs commonly in the southwestern United States and less abundantly in Mexico and Central America at higher elevations. One does not usually associate *Adelpha* with the largely arid Valle de México, and so we were surprised to find two species rather commonly in the high country of the state of Hidalgo, México, during January and February, 1969. Neither of these species is well known, and information about them, as well as comments about other related species should be informative to other lepidopterists.

Adelpha donysa (Hewitson)

Figs. 1, 2 (♂), 9 (♂ genitalia)

Heterochroa donysa Hewitson, 1847. Ann. Mag. Nat. Hist., 20: 260 (type-locality: "Mexico").

Heterochroa roela Boisduval, 1870. Lep. Guatemala, p. 46 (type-locality: "Mexique").

Adelpha pithys vodena Fruhstorfer, 1915. *In* A. Seitz, Die Gross-schmetterlinge der Erde, 5: 524 (type-locality: Guerrero, Mexico) **New synonymy.**

This species has been rather poorly known since its description. Godman and Salvin (1884, p. 305) give a rather perfunctory description of this butterfly, and Fruhstorfer's (1915, p. 524) description is useless. Indeed, it appears that Fruhstorfer may have been totally ignorant of the true nature of *donysa* and redescribed it under the name of *vodena*, though we have not seen the type of the latter name. *A. pithys vodena* was described from Guerrero, and the British Museum (Natural History) contains no material identified as *vodena* among their huge holdings from that state, although they do have some typical *pithys* (Bates) from there.

The present species bears little resemblance, except in a very general way, to *pithys*, figures of which are given here (Figs. 3, 4, ♂; 10, ♂ genitalia). The two species are in the same general group within the genus, but clearly distinct. The chief superficial characters separating these butterflies are precisely those cited by Fruhstorfer (1915, p. 524) for the separation of *vodena* from *pithys*: the reduced white median bands and the definitely darker under surface in *donysa*.



Figs. 1–4. The *adelpha pithys* group. 1, *A. donysa* (Hewitson), ♂, upper surface, México, Hidalgo, 5 mi. NW Zimapán; 2, same specimen, under surface; 3, *A. pithys* (Bates), ♂, upper surface, Guatemala, Alta Verapaz, Baleu, Mpio. San Cristóbal Verapaz; 4, same specimen, under surface.

We encountered *donysa* in two rather diverse habitats in Hidalgo and obtained a series of nineteen specimens. The butterfly was most common in a dry, very "un-*Adelpha*-like" area five miles northwest of Zimapán, Hildago, at an elevation of about 2000 m. This area was a dry scrub oak-juniper association that resembles similar habitats in the southwestern United States. The "wet" winter landscape is still arid, but the trees are with leaves, and some herbage is evident. During the summer, however, a drier place is hard to imagine; the deciduous trees are leafless, and there is no growth of annuals. The late summer rains are sporadic (in 1967 they never came) so *donysa* may be univoltine in this area. The second area was near the village of El Encarnacion, Hidalgo, at elevations be-

tween 2300 and 2400 m, a more inviting place for butterflies in general. *Eumaeus debora* Hübner, a new *Callophrys* being described by Harry Clench and *Polygonia haroldi* C. and R. Felder were among many species taken there. This locality is something of an oasis in the middle of the arid mountains of Hidalgo with tall (up to 80–100 feet) pines and oaks, apple orchards and rose gardens in the village, comparatively lush under story vegetation and a permanent stream. Fewer specimens of *donysa* were taken there than at the Zimapán locality, however, suggesting that the area was not arid enough for this unusual *Adelpha*.

Specimens of *donysa* were easiest to capture early in the morning, to about 10:00 AM, when they were sunning and flying near the ground. This butterfly will sun on the upper side of a leaf or on the ground with the wings flat and oriented to provide maximum exposure to the sun's rays, obviously a thermoregulatory mechanism (see Clench, 1966, for details). When not sunning, these butterflies will perch on the uppersides of leaves in prominent places with the wings upright or slightly open and are quite aggressive, charging at passing butterflies, birds, and collectors. The flight at this time is a glide with the wings flat until they reach the object of their aggression, then they flutter at the object vigorously and finally break contact and return to their perch. As the day progresses the butterflies move higher and higher into the canopy, and by mid-afternoon they may be seen only near the tops of trees. Oaks are preferred by the adults, and it is probable that the larvae feed on the foliage of these.

The adults show little sexual dimorphism and more closely resemble the type of *roela* than that of *donysa*. It may be that *roela* is a different, but not too distinct, subspecies; we have insufficient material at hand to make such a decision.

Adelpha creton Godman

Figs. 5, 6 (♂), 11 (♂ genitalia)

Adelpha creton Godman, 1901. *In* Godman and Salvin, 1879–1901, Biologia Centrali-Americana 2: 692 (type-locality: "Jalapa, Mexico").

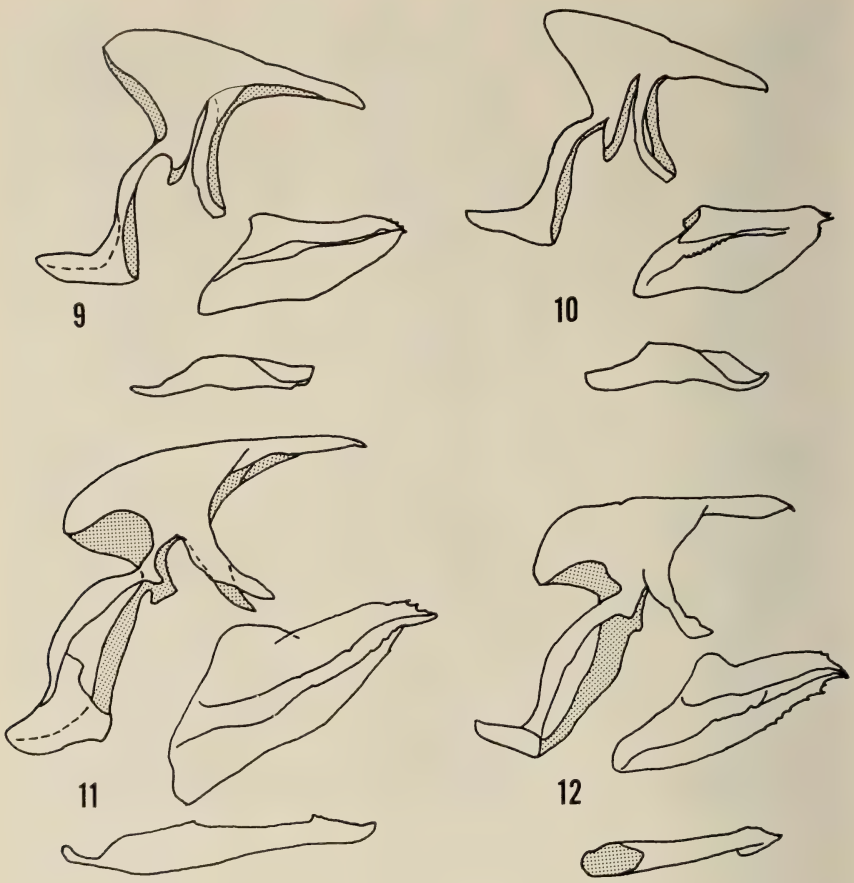
This species was described in the Supplement to the *Biologia* from a single female in the Schaus collection. Apparently the type has remained unique since its description; we have been unable to locate any other specimens in American or British collections other than the type in the U. S. National Museum (Type No. 850). In the original description *creton* was compared with *diocles* Godman and Salvin (1884, p. 303), a very similar insect from the Sierra de Talamanca, Costa Rica, and the Volcán de Chiriquí, Panamá, and it seemed reasonable that *creton* might be a subspecies of *diocles* (Figs. 7, 8, ♂ holotype; 12, ♂ genitalia). The genitalia



Figs. 5–8. The *Adelpha diocles* group. 5, *A. creton* Godman, ♂, upper surface, México, Hidalgo, vic. El Encarnacion; 2, same specimen, under surface; 3, *A. diocles* Godman & Salvin, ♂ holotype, upper surface, Chiriquí, Panamá; 4, same specimen, under surface.

suggest that the two species should be kept separate. It is interesting that Fruhstorfer (1915) completely ignores both *creton* and *diocles*, so it must be assumed that he had seen specimens of neither. Both species show pattern convergence toward the south Brazilian *abyla* complex, but the two groups are apparently derived from different stocks within *Adelpha*.

We encountered *creton* in small numbers in the El Encarnacion area throughout our stay in Hidalgo. Fifteen specimens were taken, but no more than two or three in any one day. Many were seen, but they were high in the oak trees, far out of net range. Occasionally they would glide down to ground level, alight on dirt or at mud with the wings flat and nervously move from place to place. These butterflies, to a far greater



Figs. 9–12. Genitalia of *Adelpha*. 9, *A. donysa* (Hewitson), ♂ genitalia, slide M-2112 (Lee D. Miller), México, Hidalgo, 5 mi. NW Zimapán; 10, *A. pithys* (Bates), ♂ genitalia, slide M-2111 (Lee D. Miller), Guatemala, Alta Verapaz, Baleu, Mpio. San Cristóbal Verapaz; 11, *A. creton* Godman, ♂ genitalia, slide M-2086 (Lee D. Miller), México, Hidalgo, vic. El Encarnacion; 12, *A. diocles* Godman & Salvin, ♂ genitalia, slide TGH 1962-538 (T. G. Howarth, British Mus. (Nat. Hist.), Costa Rica, Cascajal.

extent than *donysa*, were very wary and difficult to approach. The intimate association of the adults with the tall oaks of the area suggests that *creton* is also a *Quercus* feeder as a larva.

It seems unlikely that the type of *creton* actually came from the town of Jalapa, Veracruz, since that place is in a tropical forest at an elevation of about 1000 m. It seems more likely that the type of *creton* came from the flanks of Mt. Orizaba above Jalapa at an elevation in excess of 2000 m.

This is not the first time that material from the highlands west of Jalapa in the Schaus collection has been described as from the city. The scarcity of this species, and for that matter of the Central American *diocles*, may be caused by collectors seeking these butterflies in tropical habitats, more typical for *Adelpha*, rather than in the high, moist montane valley where these species occur.

Acknowledgments

We would like to thank Mr. R. I. Vane-Wright of the British Museum (Natural History) and Mr. William D. Field of the U. S. National Museum for their help in comparing our material with the types of species in the respective museums.

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THE AFFINITIES OF THE ITHOMIINAE AND THE SATYRINAE (NYMPHALIDAE)

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Fox (1956) called into question the classical association of the nymphalid subfamilies Danainae and Ithomiinae, arguing that the Ithomiinae are actually more closely related to the Satyrinae, especially the glossy-winged genera such as *Pierella*. Miller (1968) in his excellent revision of the Satyrinae quoted Fox's view and remarked on the presence of a vestige of vein 3V (3A) as "structural evidence" supporting "the obvious similar tendency of the ithomiids and the satyrines to have hyaline wings" (p. 15). As Miller noted, however, this characteristic is also shared by the danaines. There is, of course, massive morphological evidence clearly showing that ithomiine adults are more similar to danaines than to satyrines (Ehrlich, 1958, Ehrlich and Ehrlich, 1967). In this paper we present further evidence that Fox's judgement was in error.

In December, 1969, in the course of a field study of butterfly populations at the Beebe Tropical Research Station, Simla, Trinidad, W.I., we used "fedegoso" (dried plants of *Heliotropum indicum* L. (Boraginaceae) as an attractant to sample populations of ithomiines for mark-release-recapture experiments. We were impressed that this plant attracted not only very large numbers of male ithomiines (*Ithomia drymo*, *Hymenitis andromica*, *Tithorea harmonia*, *Melinaea lilis*, *Hypothyris euclea*, *Mechanitis isthmia*, and others), but also large numbers of males of the danaine, *Lycorea ceres*. No other butterflies were seen to pay the slightest attention to the fedegoso. A check of the literature reveals that Beebe himself (1955) had recorded ithomiines and both *Lycorea* and *Danais plexippus* visiting the lure. It is interesting to note here, that on Samoa and other South Pacific islands, danaines such as *Euploea* spp. and *Danais melissa* (again all males) are attracted by the dead twigs of *Tournefortia argentia*, another borage (Buxton, 1926, Poulton, 1936). An additional similarity among these isolated observations in the Neotropics and in Oceania is that amatid moths are attracted to these lures in both regions (see also Moss 1947).

Other behavioral traits link the Ithomiinae and Danainae. Both fly in the sedate manner which is typical of distasteful butterflies, and put on displays of agility only when attacked. *Pierella*, on the other hand, is one of the most rapidly flying satyrines, *P. hyalinus* displaying behavior characteristic of butterflies with "flash and dazzle" coloration. We have seen both danaines and ithomiines commonly taking nectar at flowers in the tropics, behavior rarely encountered in tropical satyrines. On the other hand, *Pierella*, *Euptychia*, and *Taygetis* all assemble on decaying fruit and are easily baited with it, but in our experience fruit baited traps have never attracted ithomiines or danaines. Similar observations on the absence of danaines on fruit baits have been made in Africa (Rydon, 1964) where danaines were much more prominent in the butterfly fauna. In *Euploea*, at least, among the danaines, males are reputed to "assemble" females (Latter, 1935). It is also strongly suspected that male ithomiines "assemble" females (Gilbert, 1969). However, this point will remain uncertain until more is known about the courtship behavior of forest danaines, ithomiines, and satyrines. Finally, both *Lycorea ceres* and all of the ithomiines we have investigated will feign death on capture, often remaining inert for up to five minutes. We have never observed this behavior in satyrines.

One might argue that these behavioral similarities are all due to the involvement of the ithomiines and danaines in mimetic complexes, and indeed they may be. It should be noted, however, that *Heliconius numata*

and *H. isabella* (Nymphalinae), and *Dismorphia amphione* (Pieridae, Dismorphiinae) are involved in a mimicry complex with *Lycorea ceres* and *Tithorea, Mechanitis, Melinaea,* and *Hypothyris* around Simla. Although these share flight characteristics with *Lycorea*, *Mechanitis*, *Melinaea*, *Hypothyris*, and *Tithorea*, they do not visit fedegoso, they do not feign death, and, at least in the Heliconiini, males do not assemble females. We consider the morphological and behavioral evidence of the closeness of adult ithomiines to danaines significant when compared to the superficial similarity in wing transparency of *some* ithomiines with a few satyrines.

Similarly, evidence from immature stages indicates close affinity of ithomiines with danaines, not satyrines. The larvae of the first two always feed on dicotyledons, the third always on monocotyledons. Both Ithomiinae and Danainae feed on plants rich in alkaloids, the former almost exclusively on Solanaceae and the latter primarily on Asclepiadaceae and Apocynaceae. Furthermore, *Tithorea harmonia megara*, one of the three New World ithomiines reported to feed on non-solanaceous plants, feeds in Trinidad on *Echites* (= *Mesechites trifida* Jacq., Apocynaceae; Guppy 1894, 1904). In Costa Rica, Fountaine (1911) reared *Tithorea "pinthias"* (= *T. tarricina duenna* Bates; see Fox, 1968) on a plant which from its description is probably *Echites* or another Apocynaceous vine. Guppy (1894) also reports finding *Sais* (= *Aeria*) *eurymedia* on *Echites* in Trinidad.

Morphologically, larvae of the danaine *Lycorea* and the ithomiine *Tithorea* are strikingly similar (descriptions in Guppy, 1894, 1904 and Fountaine, 1911 and illustrations in Guppy, 1904), and when disturbed have the same behavior of nervously twitching the long flexible protuberances which arise from the first segment behind the head. Guppy (1894) describes *A. eurymedia* larvae as almost identical to those of *Tithorea* except for their much smaller size at pupation. The larvae of such ithomiine genera as *Dircenna*, *Hypothyris*, *Ithomia*, *Godyris*, and *Mechanitis* do not superficially bear such strong resemblance to the danaines, nor to one another for that matter (Gilbert, personal observation). In any case, ithomiine larvae do not seem suggestive of the satyrines.

Müller (1884) in his classic work "Sudamerikanische Nymphaliden Raupen" pointed out two characteristics in common among danaines and ithomiines. One is primary bristle development around larval bristle 1a. The second major characteristic suggesting close relationship is the rigidity of the pupae. The only two major differences between these groups according to Müller are, firstly, that danaines possess and ithomiines lack the "Scherndornen" (long flexible protuberances), and sec-

ondly that danaines feed on Asclepiadaceae whereas ithomiines feed on Solanaceae. Unfortunately, Müller apparently never worked on the life history of *Tithorea*, which represents a major exception to both of his criteria for separating these two groups.

Acknowledgments

We would like to thank Michael C. Singer for advice in translating the Müller paper.

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A DAY-FLYING MOTH (PERICOPIDAE) NEW TO TEXAS AND THE UNITED STATES

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Phaloesia saucia Walker

Phaloesia saucia Walker, 1854. List of specimens of lepidopterous insects in the collection of the British Museum, Part 2, p. 359 (genus and species described from 4 specimens, two from Venezuela, one from Nicaragua, and one from unknown locality); Butler, 1874, Trans. Ent. Soc. London (1874) p. 54; Druce, 1884, Biol. Centr.-Amer., Insecta Lep., Het. 1: 105, t. 11, f. 2; *ibid.*, 2: 384 (1890); Kirby, 1892, Syn. Cat. Lep. Het. 1: 189, n. 1; Dyar, 1911, Proc. Ent. Soc. Wash. 13: 230; Dyar, 1914, Ins. Inscit. Menstr. 2: 63; Hering, 1925, *in* Seitz, Die Gross-Schmetterlinge der Erde 6: 448; Bryk, 1931, *in* Strand, Lepid. Cat. Part 45, p. 40.
Cocastra gentilis Boisduval, 1870, Consid. Lep. Guat. p. 88 (synonymy).
Phaloesia fulvicollis Butler, 1875, Ann. Mag. Nat. Hist. (4) 16: 171 (synonymy).
Phaloesia chalybdea Butler, 1875, Ann. Mag. Nat. Hist. (4) 16: 171 (synonymy).
Phaloesia veneszuelae Butler, 1875, Ann. Mag. Nat. Hist. (4) 16: 171 (synonymy).
The last four names were placed in synonymy by Druce (1884) to which Butler agreed.

McDunnough (1938) does not list this species as being found in the United States, even though examples had been collected at Brownsville, Cameron County, Texas 28 years earlier. Because few collectors may be familiar with this species, a male and female are illustrated. There is considerable size variation in each sex, possibly due to availability or scarcity of larval foodplant. Of the nine examples collected by the writer, the wing expanse of males ranged from 1¼ to 1½ inches, and of females from 1⅞ to 2 inches.

Dyar described the larva, cocoon, and pupa but did not give its larval foodplant. This species has been collected at or near Brownsville, Texas in April, May, August, October, and November. Collection dates would indicate there are at least three broods in extreme southern Texas where it has been taken by various collectors over the past 60 years. It is therefore considered resident.

Specimens observed and collected by the writer have been in thick brush or on the edge thereof, making it difficult to catch except when feeding on blossoms. This dense and often thorny habitat probably accounts for the tattered condition of some specimens.

The earliest known records for the United States are three examples in the U. S. National Museum. A female bears the labels "Brownsville, Tex., Nov. 30, 1910"; "Sweeping weeds, STC., Nov. 20, '10"; and "*Phaloesia*



Figs. 1,2. *Phaloesia saucia* Walker, dorsal view; Brownsville, Tex., 3.IV.1957 (R. O. Kendall). 1, Male (expanding 1.5″); 2, female (expanding 2.0″).

saucia". The other two specimens, a ♂ and ♀ collected in copula, Brownsville, Texas April 7, 1929, F. H. Benjamin (♂ very battered and worn).

The writer has collected nine examples at or near Brownsville. In April 1957 it was found fairly common, but not realizing it to be a good catch, only a few examples were taken. Specific dates are: 2 April 1957 (1♂, 2♀♀), 3 April 1957 (2♂♂, 1♀), 7 November 1969 (2 fresh ♀♀ feeding on blossoms of *Eupatorium odoratum* L.), 9 November 1969 one sight record, and 10 November 1969 (1♀). Other examples were seen on 7 November but the habitat made it impossible to catch them.

Jack E. Lipes (1962) found it at Brownsville in early May and again in August. In personal correspondence, he informed the writer of taking it in flight 7 August 1961.

Michael A. Rickard (personal communication) collected it at Brownsville 31 May 1968 (1♀), 25 October 1969 (1♂), and 8 November 1969 (1♀).

Acknowledgments

I wish to thank Dr. E. L. Todd, Systematic Entomology Laboratory, U. S. Dept. Agriculture, at the U. S. National Museum of Natural History for providing data on specimens in the U.S.N.M., for the reference citations, and for reviewing the manuscript. To André Blanchard, a very good friend and companion on numerous field trips throughout Texas, I'm grateful for photographing the specimens illustrated.

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NOTES ON THE USE OF NET-TRAPS AT PALAWAN, PHILIPPINES

In past issues of this journal, I came across two articles dealing with the preparation and use of net-traps provided with baits to catch certain species of high flying forest butterflies, especially *Charaxes* and other rarely seen nymphalids. Presently there seems no record to show that such type of traps have been tried in the Philippines.

During the writer's fourth expedition to Palawan for the further study of the biology of the rare *Trogonoptera trojana* and other papilionids of the forest, we took along huge mosquito nets. These we intended to use as a hatchery for forest butterflies, and for closeting immatures right on their host plants. With the latter, we were unsuccessful, but we found other uses for these large nets.

We selected river bends or spots where two creeks converge, and also promising creeksides, and near these we hung the mosquito nets, using nearby trees or poles to hold them. The lower edges of the nets were about five inches above the ground and held firmly with stone anchors. Between July and October, the mountain creeks and streams at Palawan have a heavy traffic of roving pierids, certain nymphalids, and some papilionids. Three nets were constantly in use. Two of medium sizes were installed permanently by the creekside, and a very large one was set at several places.

In an issue of this journal in 1958, the author discussed his experience in the use of baits to attract butterflies. This time, because of the duration of our stay in the forest, an opportunity to try baiting butterflies once more presented itself. At first we used overripe fruits of the ates (*Anonas squamosa* L.) which we placed on the balcony of our hut. This was at an altitude of about one thousand feet in a densely forested valley. Early each night, some three species of Underwing Moths often came to the bait. These moths showed a high preference for this fruit over several others like guavas, jackfruit, and papaya.

Beginning in the month of August when it was less windy than in July, we set the nets. In its early phase, our baiting attempt concentrated on the use of overripe fruits, mashed pineapple jam with rum and tid-bits from our table. In this case, we were able to collect a fine series of forest butterflies such as a female *Zeuxidia*, euthalids, *Adolias*, *Pantoporia*, *Precis*, *Phalanta*, *Eulepis*, *Charaxes*, *Libythea*, and some moths. Some of these visitors came at twilight, but most of them, by day. In a small coppice near a large creek, thousands of flies of several species swarmed into the trap.

A most astounding result was noted when, for a joke, someone placed human feces inside the trap. Since the initial result seemed to indicate that certain butterflies, especially nymphalids, showed an unusual liking for this bait, it was decided to try alternating overripe fruits and human excreta, and then concentrate on the one that proved more fruitful. In a short time, it was found that human feces placed early in the trap would attract more visitors near noon on hot days than anything else. This type of bait therefore was employed for about two months, and brought a rich harvest of nearly five hundred and fifty butterflies, some of which are hard-to-get forest nymphalids.

A list of species, taken in traps baited with human feces, follows: 220 *Eulepis delphis niveus* Roths., 105 *Vindula arsinoe palawanica* Fruh., 35 *Charaxes* of some three species, *Graphium jason*, *Papilio lowii*, *P. palawanicus*, *Phalanta*, *Cupha*, *Precis*, *Libythea*, *Appias nero palawanica* Staud., *A. albina agatha* Stgr., *Symbrenthia*, *Huphina*, *Cyrestis maenalis obscurior* Stgr., *Discophora tullia semperi* Mre., *Eurema*, and several species of skippers. Possibly, if the nets were hung at various elevations, or placed on other terrain with different vegetational associations, the catch would also include a good number of forest butterflies that are seldom seen near the ground. Smaller nets such as those described in this journal might also be effective if hung in trees where species adapted to the upper layers (emergent canopy) are likely to catch the scent of the bait used.

Along the creeksides where the nets were located, hundreds of lively pierids, such as *Appias nero* and *A. albina*, passed daily up- or downstream. While the white *Appias* were frequently attracted to the bait, the red one was seldom noted to come near it. On sunny days, the smallish Palawan *Vindula* and *Eriboea* (*Eulepis*) were active mostly between ten in the morning and a little past noon. The pierids had a similar period of flight but they were still active at three in the afternoon on sunny days. Most of the trapped *Charaxes* were males. Only rarely were females taken. Of the mountain swallowtails, it was interesting to note that two, *Papilio palawanicus* and *lowii*, were frequent visitors to the bait. There were only two or three records of the *P. polytes* being attracted to human feces.

The accidental use of large net-traps at Palawan, together with the equally unplanned introduction of human feces as bait, has brought to our collecting group at the University of San Carlos a new technique for collecting at places far from human habitations. The large size of the net easily enabled the collector to enter the trap and pick the fluttering prisoners at the net's corners where they usually retire when tired. We also noted that when we were away for two or three days, we would be greeted by an accumulated catch, unless a passing dog had messed up everything.

One handicap with setting nets on the ground or close to it, is their molestation by passing dogs and night prowlers such as civet cats, wild pigs, and bearcats. In this case, if very large nets were employed, it may fare better if bamboo poles are used as weights of the edges of the net. The corners could be anchored to the ground with pegs or stones. The firm edges would discourage animals from crawling into the bait.

This note does not present any particular design and size for the nets we employed, because ready-finished mosquito nets were used. It would be best to experiment with different sizes for use on various types of terrain.

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SOME BUTTERFLIES OF MADISON COUNTY, ILLINOIS

In the years since I've been collecting butterflies I have made numerous trips to my inlaws' country home about 1½ miles west of the crossroads community of Prairietown, Madison County, Illinois. This is about 30 miles northeast of downtown St. Louis, Missouri. When time, weather, and season allowed I have collected butterflies. Recently I was reading some old journals and the President's address by Munroe (1960, J. Lepid. Soc. 14: 1–4), along with some urgings from my wife, prompted me to write this record of my captures.

The area which was collected consists of about eight acres of mowed grass and about 14 acres of pasture land which was abandoned as such about five years ago and allowed to grow wild. There is a small pond in the mowed area around which the grass is allowed to grow to its natural height. Along the highway the grass was more or less of natural height also.

Slightly more than 950 specimens representing 56 species were captured on the 67 days that at least some collecting was done in the area. The majority of the collecting was done around the three holidays, Memorial Day, the 4th of July, and Labor Day. This by no means exhausts the different butterflies to be caught in this area for in 1969 alone I added six to my list. In addition there are nine other species I have caught in one year only.

The 56 species so far caught can normally be found in the area at one time or another according to Klots (1951, A field guide to the butterflies) and are listed below in the order of Dos Passos (1964, Synonymic list of the Neararctic Rhopalocera):

Amblyscirtes samoset (Scudder)
A. vialis (Edwards)
Euphyes vestris (Boisduval)
Poanes zabulon (Boisduval & Le Conte)
Atalopedes campestris (Boisduval)
Pompeius verna (Edwards)
Wallengrenia otho (Smith)
Polites coras (Cramer)
P. themistocles (Latreille)
P. origines (Fabricius)
Ancyloxypha numitor (Fabricius)
Pholisora catullus (Fabricius)
Pyrgus communis (Grote)
Staphylus mazans (Reakirt)
Thorybes bathyllus (Smith)
T. pylades (Scudder)
T. confusis Bell
Achalarus lyciades (Geyer)
Epargyreus clarus (Cramer)

Battus philenor (Linnaeus)
Papilio polyxenes Fabricius
P. cresphontes Cramer
P. glaucus Linnaeus
P. troilus Linnaeus

Pieris protodice Boisduval & Le Conte
P. rapae (Linnaeus)
Colias eurytheme Boisduval
C. philodice Godart

Phoebis sennae (Linnaeus)
Eurema lisa Boisduval & Le Conte

Strymon acadica (Edwards)
S. edwardsii (Grote & Robinson)
Lycaena thoe Guerin-Meneville
L. xanthoides (Boisduval)
L. phlaeas (Linnaeus)
Everes comyntas (Godart)
Celastrina argiolus (Linnaeus)

Libytheana bachmanii (Kirtland)

Asterocampa celtis (Boisduval & Le Conte)
A. clyton (Boisduval & Le Conte)
Limenitis astyanax (Fabricius)
L. archippus (Cramer)
Vanessa atalanta (Linnaeus)
V. virginiensis (Drury)
V. cardui (Linnaeus)
Junonia coenia (Hubner)
Polygonia interrogationis (Fabricius)
P. comma (Harris)
Phyciodes tharos (Drury)
Melitaea nycteis Doubleday
Speyeria cybele (Fabricius)
Euptoieta claudia (Cramer)
Danaus plexippus (Linnaeus)

Lethe portlandia (Fabricius)
Euptychia cymela (Cramer)
Cercyonis pegala (Fabricius)

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NOTES ON A BRIEF COLLECTING TRIP TO NEGROS, PHILIPPINES

A Yuletide collecting trip to the hydro-electric plant site on the island of Negros, Philippines, occasioned a four-day observation of mountain satyrids and a few nymphalids under continuously bad weather. The water power plant is located on a well-forested mountain with elevations from one thousand to three thousand feet. Deep gorges and densely forested sharp slopes are characteristic of this area, but there are good trails into the forest running in many directions from the main road. These trails have been found rich in many species of nymphalids and forest satyrids.

Several days prior to our visit, the roadsides were cleared of tall ferns and grasses. One species of grass, with stiff stems as large as pencils, secreted a sap which had fermented after a few days. This was found to attract nearly ten species of satyrs, several of *Neptis* as well as three amathusiids. So, despite the rains and fogs during our four days of collecting, we were able to pick a good number of these visitors to the stumps of the grass. I was especially interested in the two species of *Ptychandra* and three of mountain amathusiids, a *Discophora*, an *Amathusia*, and a *Clerome*. Since this species of grass is common in the area and also on several islands, the discovery will help in future expeditions to increase the catch of these types of forest butterflies. I have not as yet determined the number of days before the exuded sap begins attracting the insect visitors.

We had no chance to observe the "bait" during sunny days because we never saw the sun during our stay. Our cold nights were spent around the posts of mercury-vapor lamps to collect the numerous sphinx moths and many smaller species, as well as some three species of *Antheraea*, one of a long-tailed Luna Moth, and an interesting mountain species of *Attacus*. The use of mercury-vapor lamps at logging and mining areas in mountainous areas makes such places rich collecting grounds for moths of all kinds, including several huge beetles. Because of the findings at Negros, a formal expedition to the place is being planned for the coming hot season in the Philippines, to determine if the dry season is a better collecting time in the rain forest of Negros island. Negros has a seven-thousand foot volcano named Kanla-on with a dense forest surrounding it. The lowlands are well adapted to sugar-cane, the main crop of this province.

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THE FEEDING HABITS OF *OENEIS JUTTA REDUCTA*

A recent paper by Masters and Sorensen (1969, *J. Lep. Soc.* 23: 155–161) discussed the habits of several species of *Oeneis*. They mentioned, quoting from Eff in Brown (1957, *Colorado Butterflies*), that *Oeneis jutta reducta* McDunnough ". . . in spite of the multitude of flowers nearby never visited any." The conclusion was that this species is not a flower feeder. I have collected this insect at six locations in four counties in Wyoming. In two of these areas, it was found to be an avid flower feeder. The habitats vary from exceedingly dry lodgepole pine forests, far removed from moist areas, to the borders of willow bogs such as described by Masters and Sorensen.

The first specimens taken on flowers were collected along the Doubletop Mountain Trail, Bridger Wilderness Area, Sublette Co., Wyoming on 22 July, 1969. I took four specimens and saw others on flowers in a boggy meadow at the forest's edge. On the same date, other members of the collecting party (D. R. Groothuis, J. D. Eff, and P. J. Conway) collected additional flower-feeding specimens. The insects exhibited a preference for yellow flowers although some were seen feeding upon white ones. The

butterflies, while feeding, remained quite motionless with wings tightly closed. They seemed quite unwary and were easily approached, which is not the usual case with this species in heavily wooded areas.

Additional specimens of *O. jutta reducta* were taken on yellow flowers along a dirt road in Albany Co., Wyoming on 1 August, 1969. They were found at the edge of a very dry lodgepole pine stand.

Other specimens collected during 1969 in Sublette, Fremont, and Sheridan Cos., Wyoming were found in rather heavily wooded areas flying about rocks and deadfall as described in Brown's book.

From these observations, it must be concluded that *O. jutta reducta* does feed upon flowers in some instances. Both sexes were involved. Flower feeding was observed during the hours from 11:00 AM to 2:00 PM (MDT).

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BOOK REVIEW

Annotationes rhopalocerologicae 1970—Charles F. Cowan, Clunbury Press, Berkhamsted, Herts, England, 70 pp., 15 April 1970. $3.00 US.

"This is the second and final instalment of an addenda and corrigenda to the late Francis Hemming's 'Generic Names of the Butterflies and their Type-Species' . . ." is the opening sentence of this most interesting booklet. Col. Cowan's two contributions to the stability of nomenclature must be studied by every nomenclator and every active taxonomist. Here is a synopsis of the current part:

A. An addenda of generic names published before 1965 and omitted from Hemming's work. Thirty-two names, including eleven for American Lycaenidae by Clench and *Poladryas* Bauer, are discussed. Seventy names omitted from the index of Hemming's book are listed.

B. Comments on dates of publication of works by 17 authors, including several written by S. H. Scudder.

C. Comments on the changes made in 1964 relative to Articles 11 and 31 of the International Code. These affect forty names including several genera appearing in the Americas.

D. Comments on several cases pending before the I.C.Z.N. involving butterfly genera.

E. An analysis of emended names for genera and comment upon the justification or lack of justification for each case. Several of the forty-seven names touched upon apply to American butterflies.

F. This particular section is an index to all names commented upon by Cowan. The alphabetic list of emendations to be made to Hemming's "Generic Names . . ." is extremely useful.

G. Here are listed alphabetically: incorrect subsequent spellings and unjustified emendations, unadopted synonyms, and ghost names.

Copies of this valuable little booklet may be purchased from the author at Little Gaddesden House, Berkhamsted, Herts, England.

F. Martin Brown, *Fountain Valley Rural Station, Colorado Springs, Colorado.*

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Volume 25 1971 Number 1

THE LIFE HISTORY OF *HELIOTHIS OREGONICA* (NOCTUIDAE)

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Canada Department of Agriculture, Ottawa, Ontario

Heliothis oregonica (Hy. Edwards, 1875) is widespread in montane western North America, occurring from southern British Columbia southward in the Sierra Nevada-Cascade Axis to the Lake Tahoe area of California and in the Rocky Mountain System to southern Colorado. In western America, its altitudinal range is rather wide: in southern British Columbia, for example, it occurs at altitudes between 1500 and 6000 feet. Until recently the species was considered to be confined to the West; however, two specimens were taken in 1956 at Mistassini Post in central Quebec. A single additional specimen in the Canadian National Collection was taken at Lloydminster, Alberta, well to the east of the Cordillera, in the aspen parkland belt of the Prairie Provinces. These records suggest that the species may occur in a series of disjunct populations across central Canada.

In differing areas of the distribution, the species is in flight between the middle of May and the middle of August. The period of adult activity in any area is presumably governed by seasonal development; thus at 1500 ft. in the Vernon area of southern British Columbia it flies during the latter part of May, but at 6000 ft. in the Manning Park area it has not been taken until early August.

Heliothis oregonica has been observed on several occasions ovipositing in the heads of *Castilleja* spp. in both British Columbia and California. The species is obviously not confined to *Castilleja*, however, because partially grown larvae have been found feeding on the seed capsules of *Geranium* sp.

Behaviour

Heliothis oregonica is a day-flying species and has the compound eyes greatly reduced as in other Heliothidinae with an exclusively diurnal period of activity. On warm afternoons in the montane meadowlands that constitute its usual habitat, the little moth flies swiftly and almost invisibily from blossom to blossom. The female, with wings vibrating, moves rapidly over a *Castilleja* head and pauses only momentarily, with wings partially elevated, to deposit an egg.

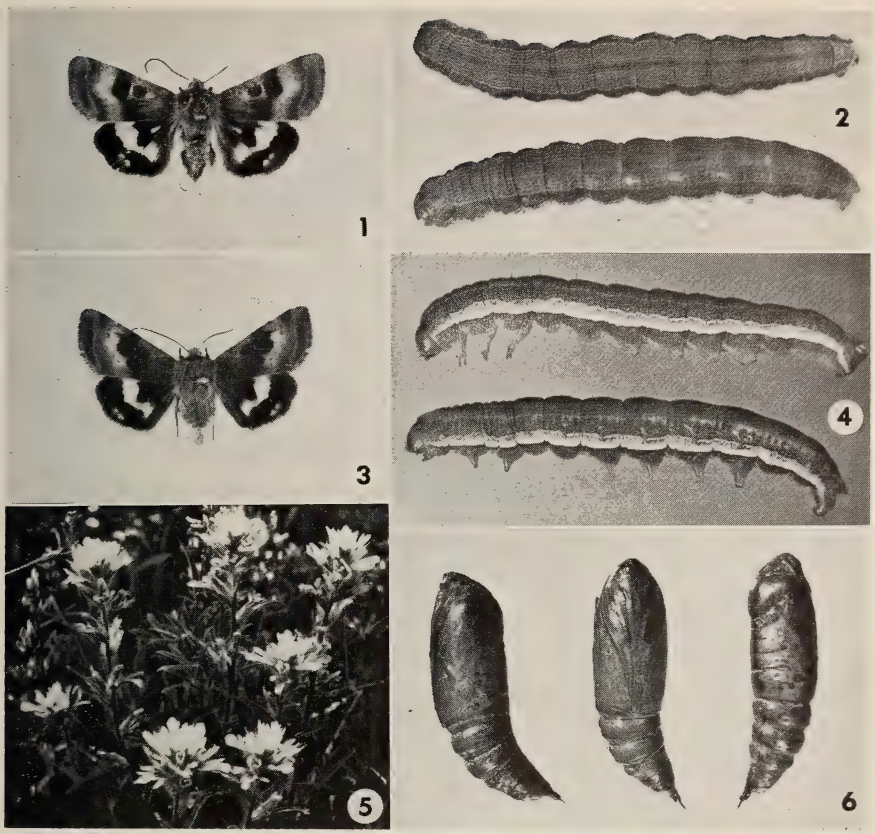
On *Castilleja* the eggs are deposited singly on the bracts, on the lip of the calyx, within the tube of the calyx or on the corolla. Three individually confined wild-caught females deposited a mean of 172 eggs, and the maximum laid by a single female was 202. A few of these eggs hatched on the fourth day after deposition but the majority hatched on the fifth day. The newly hatched larva crawls down the tubular corolla or bores through the calyx and corolla. Within the protective sheath of the corolla, the young larva feeds on the stamens, pistil and developing seed capsule. During the median stadia, the larva may usually be found at the base of a bract, its anterior end buried in the adjacent blossom on which it is feeding. Nearly mature larvae make much less effort to conceal themselves, and may usually be found feeding from a partially exposed position on the stalk. Both green and reddish-brown colour phases of larvae are probably protected from predators by their resemblance to the green stems or to the red bracts and calyxes.

Forty-seven of 58 larvae, reared individually to the pupal stage, matured in six larval stadia, the remainder in five. At the cessation of feeding, the larva tunnels into the ground to form a pupal cell. The species overwinters in the pupal stage. Available data suggest that the species is single-brooded throughout its range.

Descriptions of Stages

The following descriptions of immature stages were based on the progeny of three females taken near Vernon, B. C., and on those of two females taken near Tahoe Valley, Eldorado Co., Calif. The larvae were reared individually at room temperature on the blossoms and seed capsules of *Castilleja* spp. Rearing techniques employed were those outlined by Hardwick (1958). The estimate of variability following the mean for various values is the standard deviation.

Adult (Figs. 1, 3). Head, thorax and abdomen with an inner coat of appressed black scales and an outer coat of olive-grey hair-like vestiture; hair-like vestiture on abdomen shorter and less dense than on head and thorax. Outer vestiture on under-



Figs. 1–6. *Heliothis oregonica* (Hy. Edwards) and its food plants. 1, 3, Adults, Osoyoos, B. C., 3500 ft., and Vernon, B. C., 1200 ft.; 2, 4, dorsal and left lateral aspects of ultimate-stadium larvae, Vernon, B. C.; 5, blossoms of *Castilleja* sp. on which eggs have just been deposited; 6, pupae.

side of body paler than on upper side. *Forewing* olive-grey or olive-brown, variably suffused with reddish-brown. Transverse anterior line sinuous, angling outward between costal and trailing margins; seldom well defined, often completely obliterated. Median space cream, irrorated with olive or brown. Large, dark, usually globular orbicular, claviform and reniform spots present in basal area of median space. Basal space and basal area of median space variably suffused with olive or reddish-brown; basal suffusion often extending outward to incorporate orbicular and claviform spots, less commonly to also incorporate reniform spot. Transverse posterior line broadly excurved around reniform spot, then essentially straight to inner margin. Subterminal and terminal spaces concolorous, usually olive-brown, rarely suffused with reddish-brown; the two spaces separated by a pale-yellow or pale-grey subterminal line. Fringe concolorous with terminal space. *Hind wing* white marked with black; a black basal area, a narrow black inner-marginal band, a broad black outer-marginal band and a black blotch on disc. Black basal area usually extending outward to incorporate at least part of discal blotch. Outer-marginal band with a white median

patch. Fringe white. *Underside* of both wings pale grey marked with dark brown or black, and with pale-grey fringes; outer area of each wing darker grey than inner area. Forewing with prominent claviform, orbicular and reniform spots, and a narrow subterminal band. Hind wing with a prominent discal blotch and a variably expressed inner-marginal band; inner-marginal band forming an irregular patch at anal angle and often produced to form at least a partial outer-submarginal band.

Expanse: 26.8 ± 1.8 mm (48 specimens).

Egg. Light green when deposited. Micropylar area becoming dull red on second day after deposition. Reddish colouring becoming more intense on third day. Whole egg becoming purplish-brown on fourth day after deposition; then turning dark grey with larval head becoming visible through chorion a few hours before hatching.

Dimensions of egg: length, 0.566 ± 0.061 mm; diameter, 0.577 ± 0.023 mm (14 eggs).

First-Stadium Larva. Head and prothoracic shield black. Suranal shield dark blackish-brown. Trunk dirty yellowish-grey in young larva, becoming clear pale yellow in latter part of stadium. Setal bases and thoracic legs black.

Head width: 0.289 ± 0.012 mm (25 larvae).

Duration of stadium: larvae maturing in five stadia, 4.4 ± 0.8 days (11 larvae); larvae maturing in six stadia, 4.2 ± 0.6 days (47 larvae).

Second-Stadium Larva. Head, prothoracic and suranal shields usually dark brown; head concolorous with, darker than or paler than prothoracic shield; head occasionally rather light brown. Trunk dark dirty grey at beginning of stadium, becoming pale yellowish-green as larva increases in size; two pairs of pale dorsal lines in many specimens. Setal bases and thoracic legs black.

Head width: 0.449 ± 0.033 mm (25 larvae).

Duration of stadium: larvae maturing in five stadia, 6.9 ± 1.0 days (11 larvae); larvae maturing in six stadia, 6.4 ± 1.5 days (47 larvae).

Third-Stadium Larva. Head fawn mottled with darker brown. Prothoracic shield varying from green to pale fawn. Suranal shield poorly distinguished from trunk. Trunk varying from dark greyish-green to pale bright green; two or three pairs of rather prominent yellow lines on dorsal surface; midventral area greenish-grey, paler than remainder of trunk. Thoracic legs fawn.

Head width: 0.745 ± 0.069 mm (83 larvae).

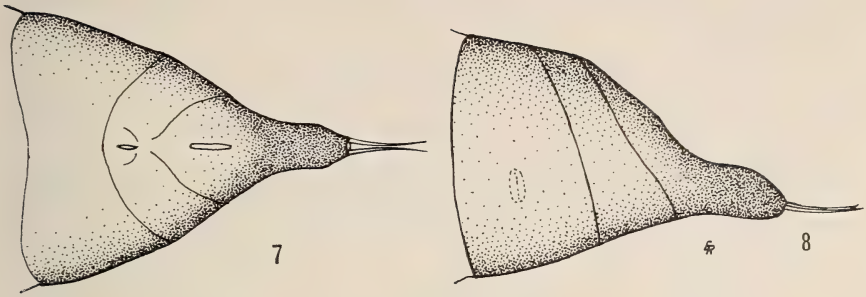
Duration of stadium: larvae maturing in five stadia, 3.3 ± 1.0 days (11 larvae); larvae maturing in six stadia, 3.7 ± 1.2 days (47 larvae).

Antepenultimate-Fourth-Stadium Larva. Head and prothoracic shield varying from yellowish-fawn to greenish-fawn. Suranal shield essentially concolorous with trunk. Trunk medium green, with a pair of dorsal and a pair of subdorsal, usually prominent, yellow lines; three narrow wavy pale lines between dorsal and subdorsal yellow lines. Lateral band prominent, the ventral half pale yellow or white, the dorsal half pale green. Ventral region of trunk greyish-green, paler than dorsal region. Thoracic legs varying from yellowish-fawn to greenish-fawn.

Head width: 1.12 ± 0.07 mm (50 larvae).

Duration of stadium: 4.0 ± 1.4 days (47 larvae).

Penultimate-Stadium Larva. Head varying from green to straw-coloured. Prothoracic shield of similar colouring to head. Suranal shield poorly distinguished from trunk. Trunk shades of green, in some specimens with a dull yellow cast. Middorsal band consisting of two or three narrow, irregular and broken lines. Subdorsal area margined dorsally and laterally by yellow lines; median band of subdorsal area consisting of two or three narrow, irregular and broken, green lines. Supraspiracular area consisting of an irregular scrollwork of narrow green lines. Spiracular band white or cream, stained with green dorsally. Ventral region greyish-green. Thoracic legs translucent green or fawn.



Figs. 7, 8. *Heliothis oregonica* (Hy. Edwards), apical abdominal segments of pupa. 7, Ventral; 8, right lateral.

A reddish-brown colour phase occasionally present among penultimate-stadium larvae.

Head width: fourth-stadium larvae maturing in five stadia, 1.41 ± 0.08 mm (23 larvae); fifth-stadium larvae maturing in six stadia, 1.74 ± 0.10 mm (26 larvae).

Duration of stadium: fourth stadium of larvae maturing in five stadia, 5.8 ± 1.4 days (11 larvae); fifth stadium of larvae maturing in six stadia, 4.6 ± 1.3 days (47 larvae).

Ultimate-Stadium Larva (Figs. 2, 4). Larva occurring in several colour phases; most larvae varying from light to medium green; a few larvae in shades of brown, dull red, or even purple. Maculation in all these colour phases essentially the same.

Head and prothoracic shield green or yellow-fawn in green specimens; brown or orange in brown or reddish specimens. Suranal shield essentially concolorous with trunk. Middorsal band presenting a complex pattern formed by the remnants of three or four narrow, badly broken, longitudinal lines. Subdorsal area similar to middorsal band, flanked on either side by narrow light-yellow lines. Supraspiracular area similar in appearance to middorsal band and subdorsal area. Spiracular band prominent; cream, white or yellow; dorsal half of band suffused with ground colour of body. Suprapodal area green or reddish-brown, mottled with grey. Midventral area varying from greenish-grey to brownish-grey.

Head width: 2.48 ± 0.18 mm (25 specimens).

Duration of feeding phase of ultimate stadium: larvae maturing in five stadia, 6.2 ± 1.1 days (11 larvae); larvae maturing in six stadia, 6.6 ± 1.6 days (47 larvae).

Duration of prepupal phase of ultimate stadium: 4.0 ± 1.0 days (54 larvae).

Pupa (Figs. 6–8). Dark mahogany-brown with a green suffusion on thorax and thoracic appendages. Spiracles on a level with general surface of cuticle; rims of spiracles very weakly projecting. Abdominal segments 5, 6 and 7 extensively and coarsely pitted; segments 4 and 8 less coarsely pitted and dorsum of segments 1, 2 and 3 rather finely pitted. Proboscis terminating between extreme apexes of wings. Cremaster consisting of two long, moderately stout setae borne at the apex of thumb-like prolongation of the tenth abdominal segment.

Length from anterior end to posterior margin of fourth abdominal segment: 9.0 ± 0.8 mm (25 pupae).

Acknowledgments

I appreciate the assistance of my associate, Mr. E. W. Rockburne, who measured the immature stages and drew the cremaster area of the pupa.

Mr. John E. H. Martin of this Institute provided the photographs of larvae and pupae.

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AMERICAN WHITE BUTTERFLIES (PIERIDAE) AND ENGLISH FOOD-PLANTS

S. R. BOWDEN
Redbourn, Herts, England

Six years ago (1964), when I offered notes on the rearing of subspecies of *Pieris napi* L., I did so "in spite of their European bias." What I had in mind was the possible non-availability of recommended food-plants in America, rather than their unsuitability for Nearctic subspecies. However, even before the notes appeared, I had run into trouble with *Pieris virginiensis* Edwards.

Most subspecies of the *Pieris napi* species-group will thrive on a variety of cruciferous plants. Even *bryoniae* Ochsenheimer, which in its Alpine habitats feeds almost exclusively on *Biscutella laevigata* L., shows no obvious preference for this plant in captivity, and does quite well on *Alliaria petiolata* Bieb. Other authors (e.g. Hovanitz & Chang 1962) have attempted systematic experiments on the choice of food by *Pieris* larvae (usually *P. rapae* L.), but it is difficult thus to demonstrate the reality of host-species preferences, unless they are sufficiently marked to over-ride possible differences in condition of the plants presented. The experiments and observations now to be described were not systematic in this sense, but by repetition and ruthlessness established certain conclusions.

Pieris virginiensis Edwards

May 1962.—Larvae hatching from Connecticut eggs of *P. virginiensis* (kindly sent by Mr. S. A. Hessel) fed on *Dentaria diphylla* Michx. leaves sent with them, but would do no more than nibble at English *Alliaria*, *Hesperis matronalis* L. and *Cardamine pratensis* L. All died. Later ex-

perience suggests that a maintained supply of *Cardamine* might have saved them.

May 1963.—Paired females from pupae received from S. A. H. laid ca. 200 eggs apparently indifferently on *Dentaria diphylla* and *Alliaria*; these were divided into *v(1)*, *v(2)* and *v(3)*.

v(1)—Forty-three eggs on *Alliaria* were kept on this plant. Although the larvae began eating the leaves, growth did not continue; many disappeared or died. After ca. 10 days only 2 survived; these were put on *D. diphylla* and then on the very local English *D. bulbifera* L. One nevertheless died; the other recovered and fed up normally (finally on *Cardamine*).

v(3)—One hundred and three eggs on *Alliaria* were further divided. Twenty-four larvae, transferred to *D. diphylla* and thence to *D. bulbifera*, suffered no check. All or most of the larvae remaining on *Alliaria* must have fed slightly, judging by the condition of the leaves; after ca. 5–7 days the three very thin survivors were transferred to *Dentaria*. Two nevertheless died, but one fed up well (finally on *Cardamine*).

v(2)—Eggs on potted *D. diphylla* were transferred to *D. bulbifera* and combined with the first 24 of *v(3)*. Three larvae, just in the last instar, were put on *Hesperis*. After some hours all 3 had left the leaves, which they had not begun to eat. The following day the same 3 larvae were again taken off *Dentaria* and were put on *Alliaria* for 24 hours; a very little of this was eaten, but it was evidently unacceptable. The larvae then fed up normally on *Dentaria*; the last 2 feeding (in Scotland) accepted *Cardamine*.

June 1964.—A further generation was bred from a single paired female. Rearing losses were very high because (1) *Dentaria* had largely died down, (2) the *Cardamine*-producing meadow had been sprayed with weed-killer. Three of the butterflies emerged without diapause.

May 1965.—Broods were obtained from a pair from fresh S. A. H. pupae *(v)* and by caging 2 such males with 3 females reared in 1964 *(u)*.

u—Eggs were all laid on *Alliaria*, none on *Hesperis* nor on *Dentaria bulbifera*. Some larvae were fed almost entirely on *D. bulbifera*. Others were transferred direct to *Cardamine*: after a slow start these grew well. Still others were transferred first to *Dentaria*, thence to *Nasturtium officinale* R. Br. (watercress), which was accepted.

v—Eggs were all laid on *Alliaria*, none on *Hesperis*. Initial rearing was on *Dentaria*: one larva on *Cardamine* pupated ca. 7 days later than its

contemporaries; two ca. 16 mm long were moved to watercress and of these one at first refused but later accepted it. A few days later the remaining larvae were given watercress. Some larvae ate old *Dentaria* petioles in preference to watercress; here, at least, the species of plant over-rode its condition.

1966–67.—Six more broods were raised, largely on watercress. One in 1967 included a very few eggs laid on *Hesperis* but none on *Cardamine*. One 1966 brood yielded a few "summer" specimens.

P. napi oleracea Harris

May 1964.—A pair, from New Hampshire pupae received from Mr. Hessel, produced only 25 eggs. *Alliaria* was supplied as food, but several larvae died and alternatives were tried: *Sinapis arvensis* L., *Sisymbrium officinale* L. and *Dentaria*. No obvious preference for any of these was shown, but there was no systematic experiment. The 9 butterflies obtained after diapause were all small except one male.

July 1965.—Pairings from 1965 pupae received from S. A. H. produced 3 large broods. The young larvae were failing on *Alliaria*, so were transferred to *Cardamine*, and later to *Sisymbrium* and *Hesperis*. Two small larvae were put on *Alliaria* only; very little was eaten and both larvae were dead in 19 days. One larva which accepted *Alliaria* proved to be an English waif.

P. napi marginalis Scudder

July 1966.—Stocks were raised from pupae (Saddle Mt. State Pk., Oregon) received from Mr. C. W. Nelson. Watercress was used successfully as larval food from the beginning. At first it was thought that *Alliaria* (as well as the horseradish *Armoracia*) had been accepted by the first batch of larvae, but some isolated larvae ate little or none of it. However, even larvae placed on *Sisymbrium* died and it became obvious that part of this brood was unhealthy.

July 1967.—A later brood was given *Cardamine* + *Alliaria*. As the remaining *Cardamine* dried up several small larvae died, but no *Alliaria* was eaten. Thereafter watercress and *Sisymbrium* were substituted.

Another brood all started to feed on *Alliaria*, but only one larva continued to do so, and this ultimately proved to be a Mediterranean stray.

June 1968.—A small batch apparently did well on *Alliaria* while young, but were then given *Sisymbrium* (on which they made slow progress), *Hesperis* and *Nasturtium*. When about 10 days old the larvae were divided: on *Alliaria* all 13 died; on *Nasturtium* 3 died and 13 pupated.

Hybrids

The breeding of hybrids of American subspecies will be described elsewhere; the account is anticipated here only to state that American-British hybrid larvae (both *virginiensis* ♀ × *napi* ♂ and *napi* ♀ × *oleracea* ♂, as well as the reciprocal hybirds of *marginalis* with Irish and British *napi*) fed normally on British food-plants, including *Alliaria*, but *virginensis* × *oleracea* hybrids rejected *Alliaria*.

Discussion

It has been known for a very long time (Verschaeffelt 1910) that Pierinae feed almost exclusively on plants united in their possession of mustard oils—Cruciferae, Capparidaceae, Resedaceae and Tropaeolaceae. Verschaeffelt also successfully induced larvae to feed on almost pure carbohydrates by flavouring them with juice containing natural mustard oils. Such experiments have often been repeated since, with various degrees of sophistication, and the analyst can now easily distinguish the various mustard-oil glucosides present in different species of Cruciferae, etc.

The evolution of oligophagy has been discussed by Dethier (1954), and the general subject of the co-evolution of butterflies and dicotyledonous plants has been admirably treated by Ehrlich and Raven (1964). As in the quoted case of Papilionids on Aristolochiaceae, it would appear that the Pierinae are a group which developed the ability to cope with a class of toxic or repellent chemical products, which then became, for them, attractants (among mammals, Hominidae appear now to be attracted by many of these same toxins). While the Coliadinae and the Dismorphiinae remained generally attached to Leguminosae, Pierinae diversified in their chosen field and became increasingly selective in respect of the combinations of volatiles demanded in their host-plants. We may suppose that in a relatively stable environment specialization in any one line normally increased until the population became confined to one or two closely related species of plants, though the choice of these might differ between conspecific populations in very different biotas.

If this is so, then we have in *Pieris* examples of "old" and "young" species: *P. virginiensis*, *P. ergane* Geyer and perhaps *P. bryoniae*; *P. rapae* L. and European *P. napi*. *Pieris ergane* provides interesting parallels with *P. virginiensis*. Another fragile butterfly of "relic" distribution, it also has n = 26 chromosomes (Lorković 1941—see also 1968) although belonging to the *napi* group which normally has n = 25; it also is re-

stricted as to food, in this case to subspecies of *Aethionema saxatile* (L.) R. Br. (Descimon 1966, Lorković 1968). Lorković's females would lay on none of 23 other crucifers.

When an oligophagous American "*napi*" is crossed with a polyphagous European (in either direction), the hybrids are polyphagous. Whether in these cases oligophagy is simply recessive was not determined. The most restricted feeder, *virginiensis*, would have to be used to obtain unequivocal results, but after the F_1 only back-crosses to the supposedly dominant *napi* were obtained.

The association between a butterfly species and its usual host-plant requires that two conditions should be satisfied: (1) the female is attracted to lay her eggs on or near the plant, and (2) the hatched larvae eat it and go on eating it. As we have seen for *P. virginiensis*, females may be super-normally attracted to a plant which the larvae refuse to continue eating. On the other hand the wild females of *P. bryoniae*, by laying their eggs almost exclusively on *Biscutella* (or locally on *Arabis halleri* L.), conceal the readiness of their larvae to accept a wide range of cruciferous plants.

If *Alliaria petiolata* were introduced to the American habitats of *P. virginiensis* it is very probable that females would lay on it initially. Subsequently either a larval variety would appear that tolerated *Alliaria*, or the tendency to lay on *Alliaria* would be eliminated—the latter is much the more likely sequel. In either case the cost of re-adaptation might be very heavy.

It is clear that the inappropriate laying of captive females on *Alliaria* is connected with the absence of this plant from the *virginiensis* habitat—otherwise the undiscriminating behaviour could not have persisted. Straatman (1962) has reported instances of four species of Australian Lepidoptera laying in the wild on introduced plants; the general sequence was that the larvae nibbled, refused to continue feeding and ultimately died. In spite of the title of his notes, Straatman provides no evidence that the plants were toxic to the larvae; it is more likely that his cases were entirely analogous to our experiments with *virginiensis*.

The other "whites," *oleracea* and *marginalis*, are not as restricted in their choice of Cruciferae, though neither will continue to feed adequately on *Alliaria*. *P. n. oleracea* has a wider range of known host-plants than *virginiensis*, and does include the latter's *Dentaria diphylla*. The survival of *virginiensis* where the two species are sympatric depends upon its closer adaptation to life in the shady woods where *Dentaria* grows (Rothke 1931, Voss & Wagner 1956). In England *P. napi* does lay on

Dentaria bulbifera, but rarely, the habitat being rather too densely wooded.

In the wild, *P. virginiensis* is reputed to be almost invariably univoltine, though as we have seen it is potentially bivoltine. Since *Dentaria diphylla* is a "spring" plant, dying back early in June, butterflies which inherited a tendency to emerge in summer would have little chance of reproduction if the larvae are in practice confined to *Dentaria*. A selective process will account for the failure of this rather southern species to produce two generations in the year, which it could otherwise easily do.

It would be of some interest to establish a colony of *P. virginiensis* in Europe. If the attempt is made it should be in an area where *Dentaria* is commoner than in England. It is to be expected that initially rather free pairing with the local *P. napi* would occur, giving polyphagous hybrids. If *Alliaria* were present, part of the eggs would deposited on it, and of these only the hybrids and back-crosses to *napi* would survive. The colony might be wiped out before a barrier of sexual discrimination could be built up. The experiment would be permissible, with such an unaggressive insect as *virginiensis*.

Summary

Not all British Cruciferae on which European *P. napi* and *bryoniae* subspecies can be raised are accepted by larvae of the American *P. napi oleracea*, *P. n. marginalis* and *P. virginiensis*. *Alliaria petiolata*, on which *P. virginiensis* actually lays preferentially, is initially attractive but larvae will not continue to eat enough of it and die of inanition. However, *Cardamine pratensis* and *Nasturtium officinale* are eaten, and the latter is recommended. In addition, *Hesperis* and *Sisymbrium* can be used for *oleracea* and *marginalis*.

European-American hybrids feed normally on *Alliaria*.

P. virginiensis is univoltine in the wild in consequence of its restriction to a "spring" plant, *Dentaria*.

The choice of food-plants by Pierinae is discussed. In a relatively stable environment, a species tends to become adapted to a very limited range of hosts. For the larvae, though perhaps not for the laying female, the optimum concentration of the attractants may be exceeded in certain plants, so that feeding ceases; or alternatively a still intolerable repellent compound may accompany the attractants.

The very specialised *P. virginiensis* has probably become increasingly adapted, over hundreds of thousands of years, to an unchanging habitat;

now its archaic condition threatens its survival. On the other hand *Pieris napi* has kept its evolutionary mobility and its subspecies have occupied a variety of environments, some still changing rapidly; in that sense the species has retained its youth.

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THE BRAZILIAN "CERCYONIS" (SATYRIDAE)

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Much confusion has occurred in the delimitation of the genus *Cercyonis* Scudder (1875). Periodically various authors have sought to unite these American butterflies with the Palearctic *Satyrus* Latreille (1810), and *Minois* Hübner (1819) whereas other authors have pointed out the distinctness of *Cercyonis*. Miller (1968, pp. 99, 120) showed that the Nearctic *Cercyonis* are members of the satyrine tribe Maniolini, and in fact, the only American representatives of this basically Palearctic tribe,

whereas *Satyrus* and *Minois* structurally belong to the Satyrini. The only representative of the Satyrini in the New World is *Neominois* Scudder (1875), from the western United States. Emmel (1969) has described the genus *Cercyonis* and by implication restricted it to the Nearctic.

The southern South American satyrid fauna has suffered from attempts to relate the butterflies found there to Holarctic genera that were familiar to the northern hemisphere systematists that first described the species. Many species belonging to the strictly American Pronophilini and Euptychini were described and long retained in such northern genera as *Satyrus* (Satyrini) and *Epinephele* (= *Maniola*: Maniolini). Such insects are illustrated particularly in the *Elina* and *Lymanopoda* series of the Pronophilini (Miller, 1968, pp. 117–118). A similar situation exists with regard to *Cercyonis*. Weymer (1912, pp. 228–230) listed the various Nearctic *Cercyonis* and includes the South American *glaucope* (C. & R. Felder) from southern Brazil and *gustavi* (Staudinger, 1897) from Bolivia. Forster (1964, p. 136) transferred the latter to the genus *Argyrophorus* Blanchard (1852), a pronophiline. The more recently described *Cercyonis leuderwaldti* Spitz (1931) must also be considered in this review of the extra-Nearctic "*Cercyonis*."

Should *glaucope* and *leuderwaldti* indeed be *Cercyonis*, a vast zoogeographic problem would arise: how did these butterflies get from the Nearctic to the southern Neotropics without leaving intervening populations, when did this occur and by what route(s)? Furthermore, to which Nearctic species are these isolated populations related? The problem is purely academic, because *leuderwaldti* and *glaucope* are not even in the same tribe, and neither is a member of the Maniolini, as is *Cercyonis*.

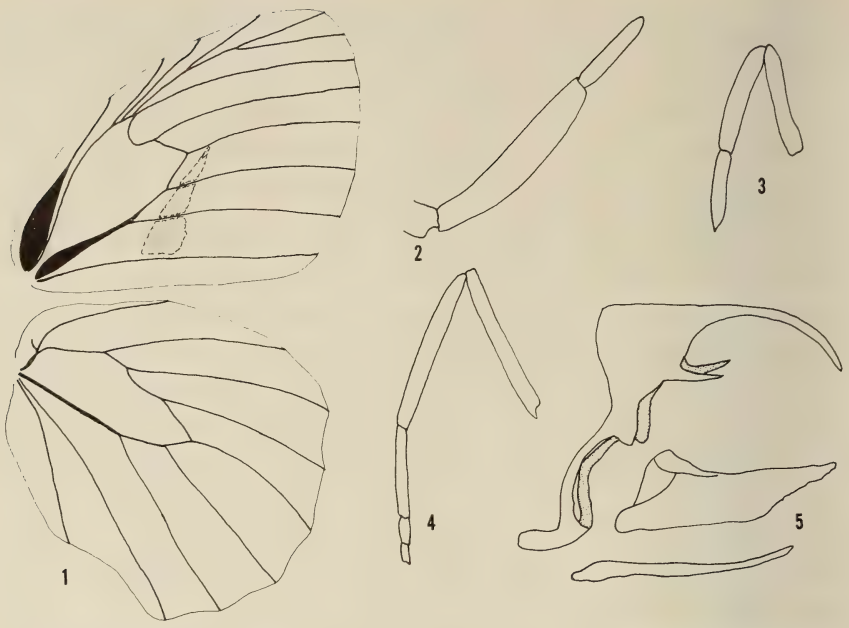
For comparison the venation, palpus, male and female forelegs and the male genitalia of *Cercyonis* are given in Figs. 1–5.

Cercyeuptychia Miller and Emmel, **new genus**

Type-species: *Cercyonis leuderwaldti* Spitz. 1931. Rev. Ent. Sao Paulo 1: 46 (Brazil).

This genus is a member of the Euptychiini and conforms in the important characters with other members of the tribe, as defined by Miller (1968, pp. 90–92). A formal description follows:

Eyes naked. Antennae short, between two-fifths and one-half length of wing; club weakly developed, occupying distal quarter of antenna and slightly more than twice thickness of shaft at its thickest point. Palpi (Fig. 7) about two and a half times length of head, erect and slightly convergent at tips; third segment two-fifths length of second, hairs of second segment less than twice greatest segmental width.



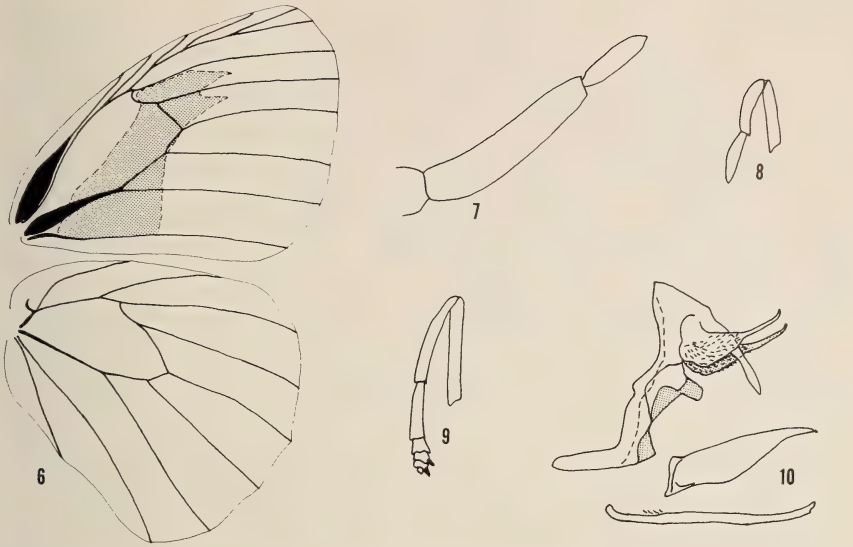
Figs. 1–5. *Cercyonis pegala* (Fabricius). 1, *C. p. alope* (Fabricius), ♂ venation (approx. 2×), Connecticut, New Haven Co., Hamden (Allyn colln.); 2, same, palpus (approx. 12×) (LDM slide M-2107); 3, same, ♂ foreleg (approx. 12×) (same slide as Fig. 2); 4, *C. p. texana* (Edwards), ♀ foreleg (approx. 12×) (LDM slide M-2113); 5, *C. p. alope*, ♂ genitalia (approx. 12×) (LDM slide M-2108).

Male foreleg (Fig. 8) reduced (forefemur-tibia-tarsus just over one-fifth length of same segments of midleg) with monomerous, unspined tarsus; femur somewhat longer than tibia. Female foreleg (Fig. 9) reduced, less than one-third length of midleg, femur somewhat longer than tibia, with a pentamerous, clubbed tarsus bearing spurs on the third and fourth subsegments. Ambulatory legs rather short, slender; midtibia less than twice length of proximal midtarsal subsegment, slightly spiny dorsad and with well-developed terminal spurs; midleg slightly shorter than hind leg.

Forewing cell square-out, slightly excavate along m_1-m_2, and about half length of forewing costa. Forewing radial veins arising from cell in two branches, Rs and M_1 arising separately, M_2 arising slightly near M_1 than M_3, Cu_1 arising nearer M_3 than Cu_2. Androconial patch of mealy and hairlike scales extending from 2A across cell to M_1-M_2, dentate distad in M_2-M_3. Sc and cubital stem inflated basally, 2A not. (Fig. 6).

Hind wing cell straight, slight distal migration of m_2-m_3 along M_2, and produced at origin of M_3: length of cell to origin of M_3 about three-fifths length of wing to end of M_3. Vein 3A slightly longer than Sc R_1, M_3 and Cu_1 arising well separated and M_2 arising nearer M_1 than M_3. (Fig. 6).

Male genitalia (Fig. 10) typical of those of many euptychiines (Forster, 1964), especially as regards the free gnathos, a condition typical of many Euptychiini, but not in Maniolini or Pronophilini. Genitalia similar to those displayed by genera



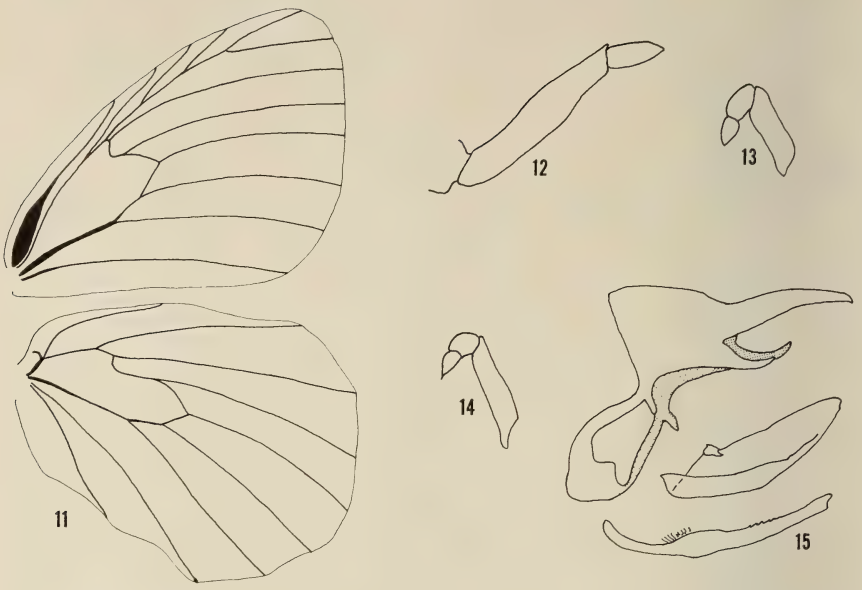
Figs. 6–10. *Cercyeuptychia leuderwaldti* (Spitz). 6, ♂, venation (approx. 2×) Brasil, D. F., Sobradinho, Brasília (Allyn colln.); 7, palpus (approx. 12×) (LDM slide M-2105); 8, ♂ foreleg (approx. 12×) (same slide as Fig. 7); 9, ♀ foreleg (approx. 12×) (LDM slide M-1724); 10, ♂ genitalia (approx. 12×) (LDM slide M-2109).

Godartiana Forster (1964) and *Praefaunula* Forster (1964), but spined gnathos typical of present genus.

The pattern of these butterflies (Figs. 16–19) is also reminiscent of *Godartiana* and *Praefaunula* with the heavily striated under surface of both wings and the lack of distinct bands that are prominent in most other Euptychiini. The well-developed ocelli of *Cercyeuptychia leuderwaldti* are only faintly indicated in any *Godartiana*, but well-developed in some *Praefaunula*, and the wings of the present genus are rounded, as in *Praefaunula*, not angular, as in *Godartiana*.

This remarkable genus is most closely related to *Godartiana* and *Praefaunula*, but quite distinct from both and immediately recognizable by the spiny gnathos and much longer penis, and from *Godartiana* by the wing shape. One of us (LDM) is working currently on the Euptychiini and considers the present genus to be somewhat more advanced than either *Godartiana* or *Praefaunula*, perhaps derived from one of them. K. S. Brown (*in litt.*) states that the present genus has comparable habits to *Praefaunula armilla* (Butler).

The name of the genus is feminine and derived from the similarity of these butterflies to the Nearctic *Cercyonis*.



Figs. 11–15. *Pseudocercyonis glaucope* (C. & R. Felder). 11, *P. g. boenninghauseni* (Foetterle), ♂ venation (approx. 2×), Brasil, S. Paulo, Campos do Jordão (Allyn colln.); 12, same, palpus (approx. 12×) (LDM slide M-2106); 13, same, ♂ foreleg (approx. 16×) (same slide as Fig. 12); 14, *P. g. glaucope* (C. and R. Felder), ♀ foreleg (approx. 16×) (LDM slide M-1725); 15, *P. g. boenninghauseni*, ♂ genitalia (approx. 12×) (LDM slide M-2110).

Pseudocercyonis Miller and Emmel, **new genus**

Type-species: *Epinephele glaucope* C. and R. Felder, 1867 [1864–1867]. Reise der . . . Fregatte "Novara" . . . Lep. Rhop., (3): 493–494; pl. 67, figs. 5, 6 (TL-"Brasilia").

This genus is a member of the tribe Pronophilini and conforms in major respects to the general characterization of that tribe by Miller (1968, pp. 110–114). A formal description follows:

Eyes naked. Antennae short, about two-fifths length of wing; club rather well developed, occupying distal quarter of antenna, about three times thickness of shaft and flattened at tip. Palpi (Fig. 12) about twice length of head, semi-porrect and somewhat divergent; third segment less than one-fourth length of second, hairs of second segment more than three times that of greatest segmental width.

Male foreleg (Fig. 13) greatly reduced (forefemur-tibia-tarsus only one-ninth length of those segments of midleg), with a stubby, monomerous, unspined tarsus; femur much longer than tibia. Female foreleg (Fig. 14) as aborted as that of male with a monomerous, unspined tarsus bearing no spurs; femur much longer than tibia. Ambulatory legs rather short and stubby; midtibia slightly more than twice

length of proximal midtarsal subsegment, sparsely spiny dorsad and with well developed terminal spurs; mid- and hind legs subequal.

Forewing cell square-cut, slightly excavate along m_1-m_2, and less than half length of forewing costa. Forewing radial veins arising from cell in two branches, Rs and M_1 approximate but separate at their origins, M_2 arising midway between M_1 and M_3 and Cu_1 arising midway between M_3 and Cu_2. No distinct androconial patch. Sc greatly inflated at base, the cubital stem slightly inflated basad and 2A not at all (Fig. 11).

Hind wing cell "stepped" distad with a definite distal migration of m_2-m_3 along M_2 and produced at origin of M_3: length of cell to origin M_3 slightly less than half length of wing to end of M_3. Sc-R_1 subequal to 3A, M_3 and Cu_1 arising well separate and M_2 arising somewhat nearer M_3 than M_1 (Fig. 11).

Male genitalia (Fig. 15) quite distinct from those of either *Cercyonis* (Fig. 5) or *Cercyeuptychia* (Fig. 10) but somewhat like those of *Argyrophorus* Blanchard, 1852 (Forster, 1964, pp. 135, figs. 168–169; Hayward, 1958, p. 254, fig. 43) and *Tetraphlebia* C. and R. Felder, 1867 (Hayward, 1958, p. 257, figs. 45, 47), but the longer, dorsally toothed penis immediately distinguishing the present butterflies.

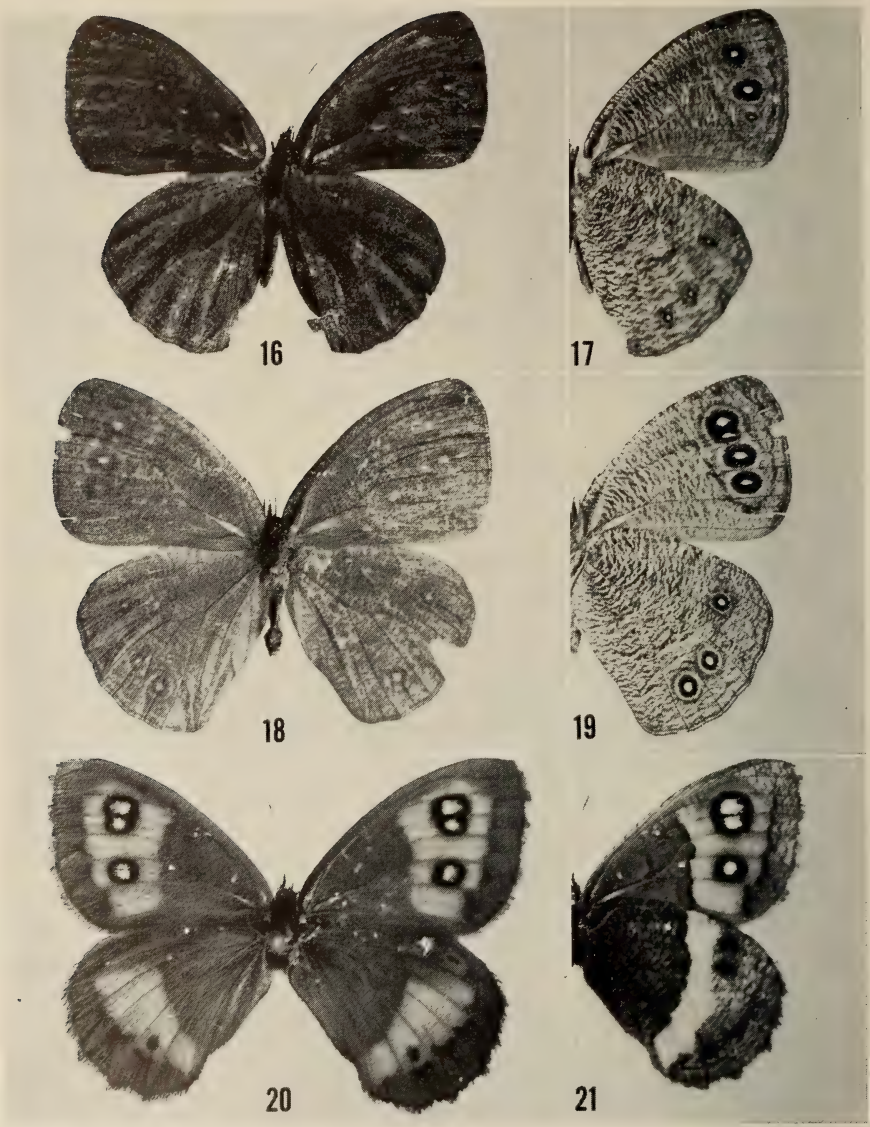
The pattern of these butterflies (Figs. 20–21) is distinctive, but somewhat reminiscent of *Tetraphlebia germainii* C. and R. Felder, 1867 (Hayward, 1958, pl. 4, fig. 161). Only by stretching the imagination could *glaucope* be considered a *Cercyonis*, but it is not easily referred to *Epinephele* (= *Maniola*) in which it was described, either.

This singular genus resembles at least the type-species of *Tetraphlebia* superficially, but genitalically it is nearest *Argyrophorus*, the type of which is the amazing aluminum colored *A. argenteus* Blanchard (1852) from the mountains of Chile and Argentina. The venation of the present genus is rather close to that of *Argyrophorus* (Miller, 1968, p. 112, fig. 279), differing in minor details; the present genus does not have a distinct androconial patch. The elongate, dorsally toothed penis of this genus is characteristic. The present genus belongs to the *Elina* series of the Pronophilini (Miller, 1968, pp. 110, 117).

The generic name is feminine and refers to the fact that the type-species was wrongly considered a member of the Nearctic *Cercyonis* by many authors.

Discussion

The southern Neotropical "*Cercyonis*" are no more members of that Nearctic genus than is true *Cercyonis* synonymous with the Palearctic *Minois*. In fact, *Cercyonis* (Maniolini), *Minois*, (Satyrini), *Cercyeuptychia* (Euptychiini) and *Pseudocercyonis* (Pronophilini) are members of totally different tribes within the Satyrinae. The similar facies and the equivalent ecological niches shown by these four genera, as well as some South African Dirini, suggest a possible adaptive advantage to a morphological appearance such as shown by *Cercyonis*, etc., even though



Figs. 16–19. *Cercyeuptychia leuderwaldti* (Spitz). 16, ♂ upper surface, Brasil, Goías, Ponte Funda (Emmel colln.); 17, same specimen, under surface; 18, ♀ upper surface, Brasil, Goías, Orizona (Emmel colln.); 19, same specimen, under surface.

Figs. 20, 21. *Pseudocercyonis glaucope boenninghauseni* (Foetterle). 20, ♂, upper surface, Brasil, S. Paulo, Campos do Jordão (Allyn colln.); 21, same specimen, under surface. *Note*: All figures approx. 1.5×.

the butterflies are only remotely related. All appear to be scrub country species, some in low country, as some *Cercyonis* and *Minois*, others at high elevations, such as other *Cercyonis* and *Pseudocercyonis*. Such assemblages of ecological equivalents are not uncommon among the Satyridae, as demonstrated by the "*Erebia* series" of unrelated montane butterflies, including the Holarctic *Erebia* Dalman (1816) (Erebiini), the *Lymanopoda* series (Pronophilini) from the high Andes, *Percnodaimon* Butler (1876) and other New Zealand Hypocystini and some South African Dirini. Careful morphological examination is necessary on members of supposedly cosmopolitan, and particularly pantropical, groups to confirm or deny relationships that have all too long been taken for granted.

Acknowledgment

We should like to thank Dr. Keith S. Brown, Jr., of Rio de Janeiro, Brazil, for providing material and observations on the ecology of the south Brazilian "*Cercyonis*."

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CONSUL PANARISTE (NYMPHALIDAE) IN VENEZUELA

I secured two fresh males of *Consul panariste* (Hewitson) on 5 and 6 February 1968 while collecting in the Venezuelan Andes with Albert Gadou of Caracas. They were taken on banana bait at approximately 1000 meters elevation on the Barinitas to Santa Domingo road in the state of Barinas. This is a humid tropical forest situation, transitional to cloud forest. Albert reported having taken previous examples of the species in the same location.

Comstock (1961. Butterflies of the American Tropics: The genus *Anaea*, p. 188) stated that *Consul panariste* is known to occur only in Colombia. *C. panariste* has been traditionally placed in the genus *Anaea*, before Comstock allied it with *Consul fabius* (Cramer) (= *Protogonius hippona* Fabricius). Although Comstock considered *Consul* to be a subgenus of *Anaea*, contemporary usage usually elevates the subgenera in his monograph to generic rank.

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SYMBIOTIC RELATIONSHIP OF AN ECUADORIAN SKIPPER (HESPERIIDAE) AND *MAXILLARIA* ORCHIDS

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On the eastern side of the Andes in Ecuador lies the small town of Puyo, the terminal point for biologists wishing to travel into the Oriente or Amazonian Basin. Lush rain forest and rich butterfly faunas are found both in the Andean foothills to the west and the lowlands to the east. The town itself is at an elevation of 3,650′. On an expedition to this region in August and September 1969, I observed a most interesting pollinating relationship, apparently mutualistic, between a large skipper butterfly species, *Perichares philetes dolores* (Reakirt), and a native arboreal orchid *Maxillaria ontoglossom.*

At the orchid gardens of Mr. Joseph Brenner, manager of the Hostoria Turingia in Puyo, a number of these *Maxillaria ontoglossom* orchids from the surrounding forest are under cultivation. On September 8, I observed a female *P. philetes dolores* visiting the flowers of these plants around 10 a.m. Mr. Brenner noted that this species of skipper, quite distinctive in size and coloration (see Fig. 1), visits these flowers daily (observations of about 18 months).

This species of skipper seems adapted specifically for feeding from and pollinating flowers like those of this long-tubed species of *Maxillaria* orchid. It has an extraordinarily long proboscis (Fig. 2). In the female I examined (forewing length of 27.0 mm, and a body length from head to tip of abdomen of 22.0 mm), the tongue was fully *43.0 mm* long when extended. This long proboscis can be flexed at any or several points by the insect, and seems perfectly adapted for probing through the extensively convoluted corolla tube to reach the nectaries.

The orchid deposits several pollinia (sticky packets of pollen grain) on the proximal end of the proboscis and these are carried on to the next flower the butterfly visits. Examination of the orchid blossoms showed that the extremely long, convoluted, and constricted corolla throat prevents entrance by bees or flies and that the nectar can only be reached by a very long-tongued insect. This skipper species was never observed visiting other orchids or flowers of any kind.

Thus it is suggested that this is a mutualistic symbiosis, with the skipper species having a guaranteed nectar source barred from other insects, and the orchid being pollinated by a specific pollinator which



Fig. 1. *Perichares philetes dolores* (Reakirt), dorsal and ventral surfaces of female.

apparently visits, at least primarily, these flowers of *Maxillaria ontoglossom* in the Puyo area of Ecuador. Since the skipper does occur north through the Neotropics (Seitz 1913), it undoubtedly uses a variety of orchids or other plant species in the various parts of its range, and it



Fig. 2. *Perichares philetes dolores* perched on lip of the orchid *Maxillaria ontoglossom*, preparatory to feeding. The proboscis is normally extended straight downward at about a 30° angle from the body plane during feeding (distal portion recurved in above sketch to conserve space).

would be interesting to have detailed data on specificity (or lack of it) in these other areas.

Acknowledgments

I thank Dr. Lee D. Miller, Curator of the Allyn Museum of Entomology, Sarasota, Florida, for identification of the skipper species, and the Organization for Tropical Studies for their support of my 1969 research expedition to Ecuador.

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FIELD TECHNIQUES FOR INVESTIGATIONS OF POPULATION STRUCTURE IN A "UBIQUITOUS" BUTTERFLY

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Because information about population structure is necessary for a proper understanding of the ecology, evolution, and geographic variation of any species of Lepidoptera, it is surprising that there have been so few effective population studies of these organisms. The investigations of Dowdeswell, Fisher, and Ford (1940, 1949), Turner (1963), Keller, Mattoni, and Seiger (1966) and Ehrlich (1965), among others, are notable exceptions. These studies have all documented essentially similar population structures, and have led to the belief that the subdivision of butterfly species into small isolated or semi-isolated populations with limited interchange of individuals is a general rule.

Studies conducted in 1962, and 1967–1969 on the satyrine *Erebia epipsodea* Butler, however, have revealed a population structure quite different from those previously reported (Brussard & Ehrlich 1970a, 1970b). We have now determined that the population studied in the vicinity of Rocky Mountain Biological Laboratory (RMBL), Gunnison County, Colorado may cover hundreds of square kilometers. There is a great deal of individual movement, and, although these butterflies are capable of recognizing and leaving ecologically unsuitable areas, these areas are not barriers that subdivide the population into smaller units.

Since the population structure shown by *E. epipsodea* may be more typical of Lepidoptera in general than the species previously studied, the purpose of this report is to describe in detail the field techniques used in determining this structure. Details of data analysis are reported elsewhere (Brussard and Ehrlich, 1970a).

When the study began, it was expected that each subalpine meadow or sagebrush flat supported a separate and distinct population, rarely exchanging individuals with adjacent areas, and that the strips of aspen and alpine fir that divided the meadows into discrete units would also serve as the boundaries of the butterfly populations. A capture-mark-recapture program initiated in 1962 used several meadows in the vicinity of RMBL as individual sampling areas. Analysis of the results of this program revealed that out of 735 butterflies collected, marked, and released in 5 localities, less than twenty percent were ever recaptured—far less than one would expect from examining the results of similar studies. Nevertheless, approximately eighty percent of the butterflies recaptured were taken in the area of previous capture. There was no way to determine whether these paradoxical results were caused by high mortality, large population size, or undetected migration.

Additional complications were caused by the short flight season of *E. epipsodea* in this area (approximately three weeks, the exact dates varying somewhat with elevation) and the unpredictable weather characteristic of early summer in the high, mountainous regions of Colorado. In late June and early July the mornings are often cool and cloudy, followed by a brief period of relatively clear sky from mid morning to early afternoon. Clouds and thundershowers usually follow from mid afternoon to early evening. Since it had been shown that *E. epipsodea* does not fly at all in temperatures below 14° C and in any numbers below 18–19° C, nor does it fly when a strong wind is blowing or when the sun is obscured by clouds (Brussard & Ehrlich, 1970c), the time available for collecting in any one day was limited. Any capture-recapture analysis is based on the assumption that marked animals have had time to mix freely with the remainder of the population before recapture. Thus, in order to study the population structure of this insect, it was decided that large numbers of *E. epipsodea* must be marked, released, and recaptured in a systematic manner within the limited period of time available. Furthermore, the sampling program must be designed to (1) give accurate population size estimates and (2) provide quantifiable information on inter-area movement. The development of a systematic sampling program in 1967 gave results which suggested the true nature of the

population structure of this insect. Modifications of this program in 1968 verified and refined the results of the previous year.

Because of the restrictions imposed by the alpine environment, and the large number of butterflies flying in the study areas, it was necessary to develop techniques for rapid handling of the insects in the field. A rapid marking technique was needed, since methods previously described (see, for example, Dowdeswell, Fisher, and Ford 1940 and Ehrlich and Davidson 1960), are far too slow or involve too many people in the marking process. It was found that the "Sharpie" marking pen, manufactured by Sanford's, was the most satisfactory marking device. Because of the fine point, good ink flow and rapid drying, one person using this pen could mark the butterflies quickly and efficiently. Furthermore, the "Sharpie" is available in several colors, each of which can be distinguished from the other after application. Although the color black tended to dry on the tip of the instrument if it were not instantly capped after applying a mark, this difficulty was not experienced with any of the other colors.

Weather permitting, collecting began around 0900 and continued for approximately one hour. The butterflies were netted and placed in individual glassine envelopes which were stored in styrofoam ice chests kept at convenient spots within the study areas. After all butterflies observed in an area had been captured, they were removed from the envelopes with forceps and examined. The recapture event was recorded for marked individuals; freshly caught ones were assigned a number and marked. In addition to date and area of capture, sex and condition were recorded at the time of initial capture and at every subsequent recapture. Damaged individuals or those exhibiting abnormal flight behavior upon release were not returned to the population. There is no evidence that there were any differences in behavior or probability of recapture between marked and unmarked individuals.

The numbering technique used was a modification of the method described by Ehrlich and Davidson (1960). The modifications included adding additional spots near the base of each wing which were assigned values of 100, 200, 400 and 700, increasing the number of individuals that could be marked, per color, to 1000 (Fig. 1). Because of this, and since the "Sharpie" is available in several colors, it was possible to give individual numbers to all butterflies marked in 1968. (In 1967 most insects were individually numbered; however, some were marked with a code pattern indicating area and date of capture.) The advantages of individually numbering all butterflies handled during a flight season are

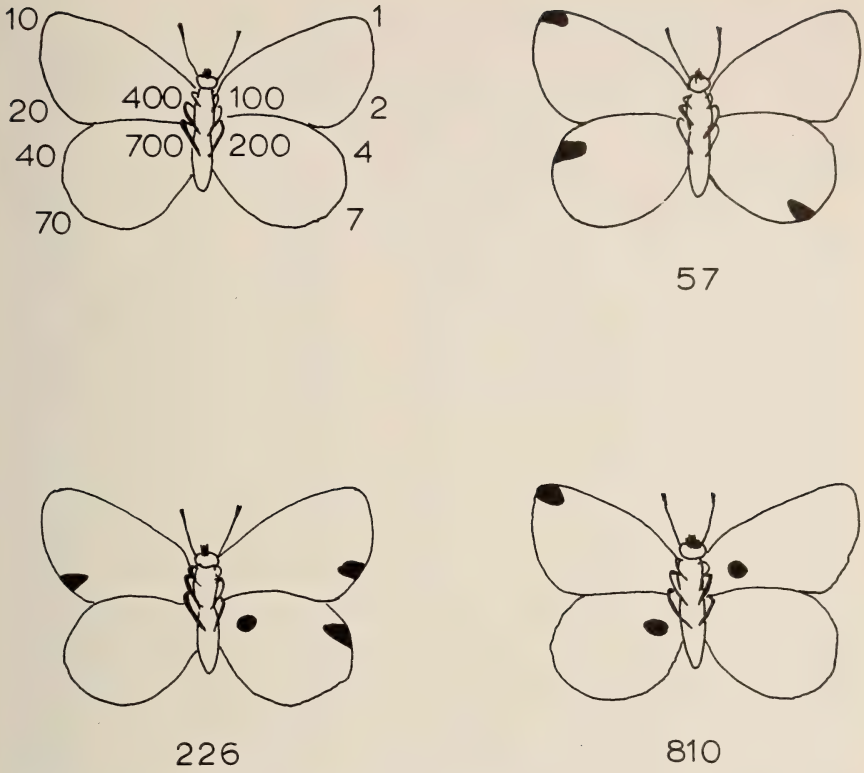


Fig. 1. Modification of Ehrlich and Davidson's (1960) marking system; 1000 butterflies per color can be marked in this fashion.

obvious; considerably more information is accumulated on individual movement, and many more partial histories of recaptured insects can be compiled.

The manner of release of animals as vagile as butterflies assumes great importance in population studies. In order to evaluate the possibility that an abnormally high level of activity occurred subsequent to release, causing excessive dispersal out of the study areas, on two occasions the butterflies were held and released in late afternoon under cloudy conditions. Collecting was delayed the following morning giving the butterflies an opportunity to mix freely with the remainder of the population prior to recapture. The percentage of recapture for that day was then compared to both the day preceding and the day following when normal release procedures were followed. Since there was no significant difference ($p >> .05$), it was assumed that the marking pro-

TABLE 1. Summary of Capture-Recapture Results, 1967

Locality	Days used	Sex	Marked & released	Number of individuals recaptured	% of individuals recaptured	Total number of recaptures*
Visquene Meadow	7	M	204	14	6.4	14
		F	13	0	0	0
Cemetery	11	M	354	123	34.7	180
		F	32	4	12.5	4
Bench Meadow Area	4	M	147	6	4.1	6
		F	3	0	0	0
Naked Hills Peninsula	4	M	111	19	17.1	19
		F	6	0	0	0
Wilson Ranch	4	M	66	2	3.0	2
		F	3	0	0	0
Gothic (combined data for two adjacent plots)	7	M	211	121	57.3	142
		F	72	22	31.9	23

* includes multiple recaptures

cedure did not cause excessive dispersal. An attempt was also made to release the butterflies at points scattered throughout the study area to facilitate free mixing with the rest of the population.

When the capture-recapture program was resumed in 1967, six localities were chosen on the basis of accessibility and apparent abundance of butterflies. In these localities 1222 butterflies were marked and released and an additional 1259 butterflies were captured and examined in peripheral areas. Examination of these data (Table 1) showed that (1) large plots surrounded by even larger expanses of ecologically suitable habitat gave exceedingly small recapture percentages, no matter how long they were sampled (Visquene Meadow, Bench Meadow, Wilson Ranch). (2) Large plots isolated or semi-isolated from other suitable areas gave higher recapture percentages, and the percentages improved with the length of the sampling period. (Cemetery, Naked Hills Peninsula). (3) Two small, adjacent plots, semi-isolated from other areas of suitable habitat and intensively sampled for relatively long periods of time (Gothic) gave satisfyingly high recapture percentages; furthermore, the positioning and size of these plots made it possible to calculate move-

ment of individual butterflies between them. However, when these data were further analyzed in order to get daily population size estimates, it was found that the estimates were highly erratic and not in keeping with field observations. In contrast to the erratic fluctuations in population size estimations from data from the small plots, those estimates made for the larger area (Cemetery), were considerably smoother and tallied more with field observations. The analytical method employed for these estimations was the stochastic model developed by Jolly (1965). The possibility that the difficulties in estimation, especially in the smaller plots, might be reduced by employing a different method of analysis was considered, although the advantages of stochastic models in general and Jolly's method in particular have been pointed out by Southwood (1966). Since the possibility existed that the Jolly method might not be entirely suitable for *E. epipsodea*, these results were compared with results derived from the deterministic models of Dowdeswell, Fisher, and Ford (1940) and Bailey (1951, 1952). In each case the estimates from these deterministic models were consistently 40% to 60% lower than the Jolly estimations. Indeed, on several days, the daily population size estimates based on Bailey's method were lower than that day's catch.

It was concluded, therefore, that the Jolly method was the most suitable analytical tool and that the size of the study plot assumed considerable significance in the estimation of population parameters. The 1968 sampling program, therefore, was designed to gather additional data amenable to analysis by this method.

It had been established during the 1967 season that one worker could usually capture all the *E. epipsodea* flying in an area of approximately 1 hectare (2.5 acres) in one hour. During peak flight season this was approximately 75 insects (Brussard and Ehrlich, 1970a). It was also found that one collector could not adequately cover areas too much larger than 1 ha during the time available for collecting and capture enough butterflies to ensure that recapture percentages were high enough for analysis. In order to utilize an area large enough to give reasonable population size estimates, we employed, in 1968, three field workers for the Cemetery area, trimming the area somewhat (from 7.6 ha to 5.5 ha) to ensure thorough coverage. Since direct evidence of movement of butterflies from site to site along with evidence of re-immigration would provide the main support for the type of population structure that has been advanced for *E. epipsodea* (Brussard and Ehrlich, 1970a), it was also necessary to establish smaller study plots that could be simultaneously covered by each field worker so that these types of data could be

accumulated. To this end, the Gothic area was expanded to include 3 contiguous plots of approximately 1 ha which were sampled simultaneously for 11 days. It was then possible to document thoroughly movement between areas and to estimate its magnitude. The 1968 results confirmed that dispersal and re-immigration did explain the difficulties encountered in obtaining the population size estimates in the small plots (Brussard and Ehrlich, 1970a).

The techniques developed here appear to be very useful in studies designed to establish density and population structures of diurnal Lepidoptera, especially those which appear to be more or less continuously distributed in their habitat, without ecological "barriers." The results of extensive studies such as these are a prerequisite for (and may largely determine the methods to be used in) intensive studies designed to delineate those factors that cause or regulate fluctuations in population size. Many more data pertinent to these phenomena are needed before the important controversy concerning density dependent or density independent population size regulation can be resolved.

Acknowledgments

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LEPIDOPTERA IN THE UNPUBLISHED FIELD NOTES OF HOWARD GEORGE LACEY, NATURALIST (1856–1929)[1]

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Howard George Lacey was born 15 April 1856 at Wareham, Dorset, England. His elementary education was received at Charterhouse, Hampshire; he studied at Frankfurt, Germany and later received a B.A. degree from Cains College, Cambridge. Although educated for the ministry, he soon gave up this career for that of naturalist. At the age of 26 he came to the United States, arriving in New York 17 June 1882, and proceeded to Kerrville, Texas where he arrived 30 June. Here he bought a ranch in the hill country about seven miles southwest of Kerrville on Turtle Creek (Figure 1) where he spent the next thirty-seven years raising livestock and studying the natural history of the area.

Lacey was a member of the Bournemouth Scientific Society, San Antonio Scientific Society, National Geographic Society, American Audubon Union, and American Ornithologists' Union. He collaborated with the Smithsonian Institution, U. S. Department of Agriculture, and other institutions for the advancement of natural science.

So far as can be determined, he published no scientific papers. Instead, he chose to collect biological specimens which were sent to various contemporary taxonomists and natural history museums. Many of his field collections and observations were recorded in a ledger which is the basis for this account. His ledger is now in the Witte Memorial Museum Library, San Antonio, Texas placed there by his sister Miss Beatrice Lacey.

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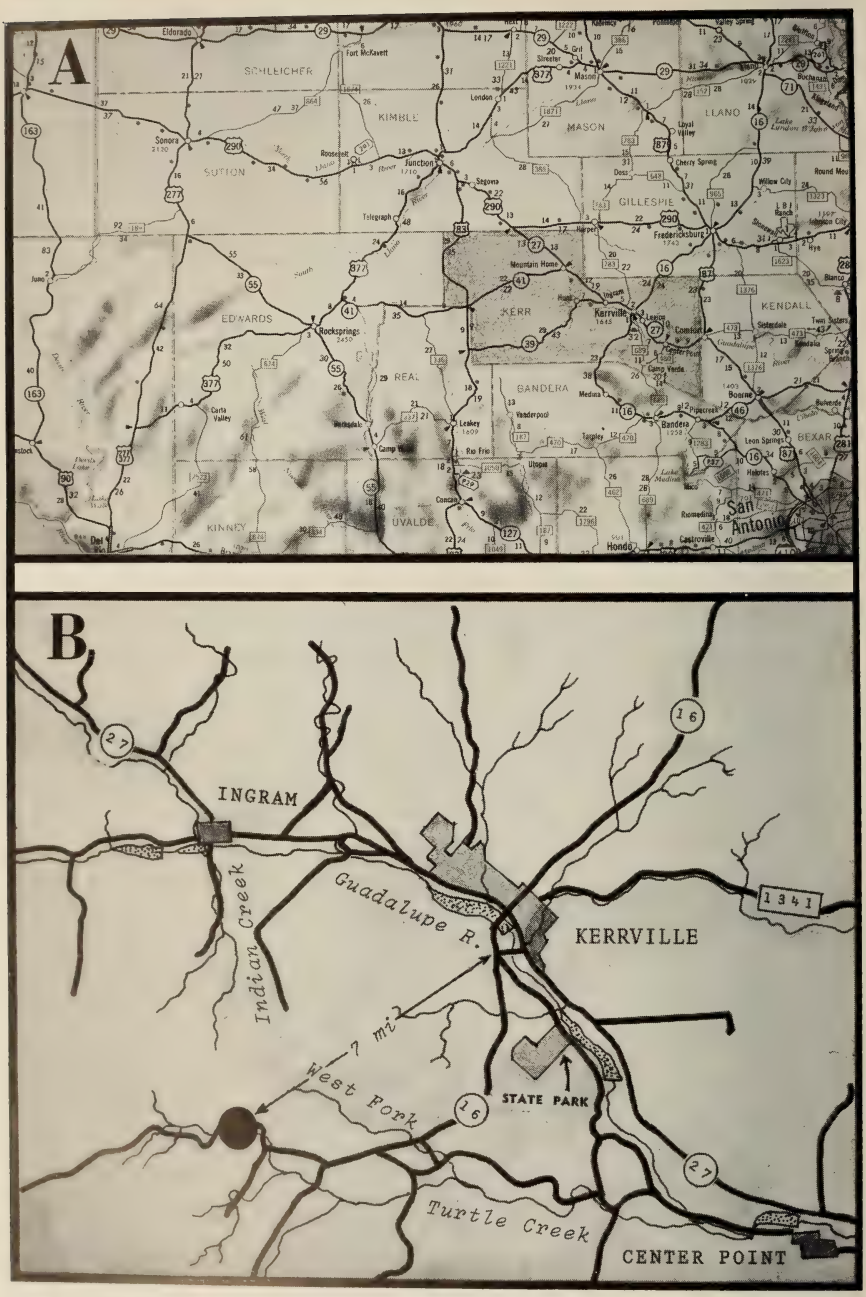


Fig. 1. A, Kerr and surrounding Texas counties; B, location of Howard G. Lacey's ranch in relation to Kerrville, Texas.

Some of the botanical and biological specimens named in his honor are: *Quercus laceyi* Small, *Strymon laceyi* Barnes & McDunnough, *Graptolitha laceyi* Barnes & McDunnough, *Logoa laceyi* Barnes & McDunnough, *Peromyscus boylei laceyi* Attwater, and *Reithrodontomys laceyi* Attwater. Only the last two were mentioned in his field notes.

Lacey's primary interests were birds and mammals of which he made numerous records. Later he became interested in Lepidoptera. The first and last recorded notes pertaining to Lepidoptera were 28 October 1882 and 23 April 1919 respectively. On 10 April 1898 he wrote: "Saw indigo bird and caught a few butterflies for Dr. Barnes. I intend to study the butterflies of the neighborhood from this date."

His collecting was not limited to butterflies. Many moths were collected, apparently at lantern light. Although most of the specimens were sent to taxonomists and institutions, he also accumulated a personal collection. On 16 May 1902 he wrote: "W. G. Dodge came over from Kerrville to see the butterflies."

Preparatory to moving back to England (8 Aug. 1919), Lacey left his local Lepidoptera collection with C. Stanley Coppock, an intimate friend, who had also come from England and settled at Kerrville a few years after Lacey. In 1925, Mrs. Ellen S. Quillin, then director of Witte Memorial Museum, attempted to obtain the collection for the Museum. Still later, his field notes were acquired. Excerpts from correspondence between Mrs. Quillin and Miss Beatrice Lacey, sister of Howard, disclose what happened.

On 25 March 1934 Miss Lacey wrote: "I have been thinking things over since my last letter to Mr. Coppock. . . . I feel Howard would like me to give his notes and diary to the Witte Memorial Museum if you say they will be of use, and will be taken care of. It hurts to part with them, but I would rather feel they are of use when I have passed over and Howard would like them to be of use I feel sure. I ask you to accept them in his name and mine with all good wishes."

Mrs. Quillin's reply of 11 April 1934 stated in part: "I received your letter this morning in which you are transferring to us as a gift the lifetime notes of your brother. I certainly believe you are doing the right thing and that Mr. Lacey would approve were he here, because when Mr. Lacey visited this Museum, at that time only two school rooms thrown together to make a Museum, the last time he was in Texas [1925] and the Attwater collection had just been added, he expressed his regret that the butterfly and moth collection he had made could not go with the Attwater collection. It seems that when he left his collection with one

of the Coppock children [1919] bugs got into some of it and other specimens were sold off. He said that the selling was with his consent inasmuch as he had then given up Texas ever getting a Museum in which to place them. That summer [1925] after he left I tried to locate the collection and found that it was held for sale. Mr. Lacey had given me only his verbal wish and I, therefore, could not push the matter.

"We have had made a typewritten copy [300 pages] of Mr. Lacey's notes which I bound last week so that scientists of note might use them for reference without in any way fingering or tearing the originals. The original books will be taken to be bound this afternoon and from then on will be placed under lock and key in my own office."

Lacey's field notes are a veritable data bank on the local flora and fauna. Most of his collecting was done at or near his ranch. Each time he ventured far from the ranch an entry was made in his field notes. For those museums having specimens collected by Lacey with dates, but without locations, the following may be of help. Dates are inclusive.

28 February–27 October 1888, trip to England and return.

8 May 1893–10 April 1894, trip to England and return.

3–23 November 1896, hunting trip on Nueces River and Frio Divide. [Apparently Uvalde County Texas.]

15–26 July 1898, fishing trip to Paint Creek. [This creek empties into the South Llano River. Most of it lies in northeast Edwards County Texas.]

25–26 June 1899, to San Antonio [Bexar County Texas].

27–[28] June 1899, went to the Medina [River] and back the next day. [Apparently in Bandera County Texas.]

26 July–5 August 1899, went to the Llano [River] fishing and had a very jolly trip. I got no new butterflies but took several very dark specimens of *T. damon* [*Callophrys gryneus castalis.*] [Apparently Kimble County Texas].

15 November–14 December 1899, our usual hunt on the Frio [River]. [Uvalde County Texas.]

7–19 July 1900, fishing on Llano River. As there were no flowers out I got only a few [butter] flies. On July 17th when we started home the South Llano was up about five feet. [Probably Kimble County Texas.]

25–30 July 1901, got back to town after a short trip to the Llano [River] with Carr and company. We camped a few miles above London. *Elada* [*Texola elada*] was about the only butterfly about. [London is in northeast Kimble County Texas.]

27 August 1901–29 March 1902, trip to England and return. Got back to the ranch little before sundown.

13–27 July 1902, fishing trip to Llano [River] camped near head of South Llano River. [Edwards County Texas.]

10–31 July 1904, fishing on Llano River. Few [butter] flies as bloom was very scarce. [Probably Kimble County Texas.]

17 July–2 August 1907 (19–31 July in camp) on fishing trip to the San Diego River in Mexico via San Antonio and Del Rio, Texas.

15–31 July 1909, fishing trip to Devils River. [Val Verde County Texas.]

23 November–6 December 1916, hunting trip to Paint Creek [Edwards County Texas].

16 July 1919, sold my ranch and stock. After selling the ranch, I put in a day or two loafing around Kerrville and then spent a week on Paint Creek swimming near the spring. Eagles, I think, used the nest on the bluff above the springs and the herons seem to have increased in numbers; nine nests in the big tree. [Apparently this was one of Lacey's favorite spots.]

8 August 1919 he left Kerrville, Kerr County, Texas for his native home in England. Still fascinated by the wonderful Hill Country of the Edwards Plateau and drawn by the devoted fellowship of old friends, he returned to Kerrville in summer of 1925 for a short but last visit, health failing. He died 5 March 1929 at the home of his sister, Miss Beatrice Lacey, 50 Wellington Road, Bournemouth, England.

In the following list of Lepidoptera mentioned in Lacey's field notes, arrangement generally follows dos Passos (1964) for the skippers and butterflies, and McDunnough (1938) for the moths. The italicized name is the species most likely collected or observed by Lacey; often he recorded only the species name. The exact citation given by him is shown below the complete scientific name. Following this are the dates and locations of specimens collected (c) or observed (s). If he gave a quantity, this too is shown. Example: (c-3) or (s-1) means he collected three, or saw one. Other pertinent remarks from his field notes are also given. Statements in brackets are those of the authors. If a specific county is not given, it may be assumed that Lacey collected or observed the specimens at or near his ranch located about seven miles southwest of Kerrville, Kerr County, Texas.

Of the 144 species of Lepidoptera recorded by Lacey, several are no longer to be found in the Kerrville area, probably due to extensive grazing by domestic sheep and goats. A few species could be considered only

strays even at the time collected. He recorded migratory flights of *Krico-gonia lyside*, *Libytheana bachmanii*, and *Danaus plexippus*.

Lepidopterous species collected by Lacey and included in the list but not recorded in his field notes are: *Tmolus azia* (Hewitson), *Strymon alea* (Godman & Salvin), *Chlosyne endeis* (Godman & Salvin), *Cale-phelis rawsoni* McAlpine, *Graptolitha laceyi* Barnes & McDunnough, and *Lagoa laceyi* Barnes & Dunnough.

Megathymidae

***Megathymus coloradensis kendalli* H. A. Freeman** 1965. "M. yuccae". 8-IV-1900 (c), 15–IV-1900 (c), 15–III-1901 (s), 17-III-1901 (c-1 ♂), 18-III-1901 (s-2), 19-III-1901 (c), 20-III-1901 (c), 22-III-1901 (s), 12-IV-1901 (s), 18-IV-1901 (c), 4-IV-1902 (s), 7-IV-1902 (c), 22-IV-1902 (c), 30-IV-1902 (s), 1-IV-1903 (s), 26-IV-1903 (c-1 ♀), 10-V-1903 (s), 24-III-1910 (s), 2-V-1913 (c), 4-V-1913 (c). [Have recent records, but scarce.]

Hesperiidae

***Panoquina ocola* (Edwards)** 1863. "Ocola". 19-VIII-1907 (c-3), have not seen it since 1899. [Should be found occasionally.]

***Lerodea eufala* (Edwards)** 1869. "Eufala". 18-III-1900 (c), didn't see *eufala* all last year, the year before it was common; 11-IV-1901 (c). [Have recent records.]

***Amblyscirtes aenus aenus* Edwards** [1878]. "Amblyscirtes aenus". 23-IV-1899 (c-3), 23-IV-1903 (c), 26-IV-1903 (c). [Have recent records.]

***Amblyscirtes oslari* (Skinner)** 1899. "Oslari". 15-IV-1900 (c). [Have recent records.]

***Amblyscirtes nysa* Edwards** 1877. "Nysa". 24-III-1900 (s), 15-IV-1900 (c), 1-IX-1900 (c), 4-IV-1901 (c), 18-VI-1902 (c), 13-27-VII-1902 (c) [Edwards Co.], 23-IV-1903 (c). [Have recent records.]

***Amblyscirtes eos* (Edwards)** 1871. "Comus". 28-III-1900 (c), 1-IX-1900 (c), 22-III-1901 (s), 11-IV-1901 (c), 24-IV-1902 (c), 18-IV-1903 (c-5). [No recent records, but should be found occasionally.]

***Amblyscirtes celia* Skinner** 1895. "Celia". 1-IX-1900 (c), 11-IV-1901 (c). [Have recent records.]

***Euphyes vestris metacomet* (Harris)** 1862. "Vestris". 15-IV-1900 (c), 1-IX-1900 (c). [Have recent records.]

***Atrytone delaware lagus* (Edwards)** 1881. "H. delaware". 11-VIII-1901 (c), 21-VIII-1901 (c-5). [No records since 1901, but should be found rarely.]

***Wallengrenia otho egeremet* (Scudder)** 1863. "Otho". 1-IX-1900 (c). [Have recent records.]

***Polites vibex praeceps* (Scudder)** 1872. "Brettus". 28-VIII-1907 (c-1 ♀), have not seen it here before. [Have recent records.]

***Hesperia viridis* (Edwards)** 1883. "E. nevada". 11-II-1901, caught *E. nevada* in my hand but let it go as I had nothing to put it in. [Have recent records.]

***Hylephila phyleus* (Drury)** 1773. "Phylæus". 11-IV-1901 (c). [Have recent records.]

***Copaeodes aurantiaca* (Hewitson)** 1868. "Procris". 10-IV-1902 (s). [Have recent records.]

***Lerema accius* (Smith)** 1797. "L. accius". 3-I-1905 (c), 29-X-1916 (c).

Not often seen but has been common at morning glory vines at the house. [Have recent records.]

***Pholisora catullus* (Fabricius)** 1793. "Catullus". 6-IV-1900 (s), 18-III-1901 (s), 13-27-VII-1902 (c) [Edwards Co.], 5-XI-1902 (c-2). [Have recent records.]

***Celotes nessus* (Edwards)** 1877. "P. nessus". 27-III-1900 (c), 30-IV-1901 (c), 18-VI-1902 (c), 13-27-VII-1902 (c) [Edwards Co.]. [Have recent records.]

***Heliopetes domicella* (Erichson)** 1848. "P. domicella". 23-VIII-1916 (c). 23-VIII-1916 (c).
[Stray, no recent records.]

***Heliopetes laviana* (Hewitson)** 1868. "Ericetorum". 11-VIII-1907 (c). A day or two ago I got two white hesperids (*Ericetorum*). [So far as we know *Heliopetes ericetorum* has not been taken in Texas. *H. laviana* occasionally occurs at San Antonio, New Braunfels, and Austin. It could very easily range over to Kerr County in a good year.]

***Pyrgus communis communis* (Grote)** 1872. "P. tessellata". 25-II-1900 (c-2), 8-III-1900 (s), 21-I-1901 (s), 5-XI-1902 (c). [Have recent records.]

***Erynnis brizo* (Boisduval & LeConte)** 1834. "N. brizo". 21-II-1900 (c), 8-III-1900 (s), 10-IV-1902 (c). [Burns (1964) located three hybrid examples in museums from Kerr Co. Texas without dates; these could be them. Burns and the Kendalls have collected the area without finding *E. brizo*.]

***Erynnis zarucco funeralis* (Scudder & Burgess)** 1870. "N. funeralis". 27-IV-1899 (c-1), 14-III-1900 (c), 13-IV-1900 (s-fresh), 18-V-1901 (c), 5-XI-1902 (c). [Have recent records.]

***Erynnis martialis* (Scudder)** 1869. "N. martialis". 20-III-1899 (c-several), 17-IV-1899 (c), 25-III-1900 (c-1), 13-III-1901 (c-several). [Burns (1964) located five museum specimens with incomplete dates from Kerr Co. Texas. These dates should help fill the void. No records since 1901. Careful searching by Burns and the Kendalls have failed to locate this species in the Kerrville area.]

***Gesta gesta invisus* (Butler & Druce)** 1872. "Nisoniades llano". 13-27-VII-1902 (c), fishing trip to Llano River, camped near head of South Llano [River] [Edwards Co.]. 10-31-VIII-1904 (c-1) [Kimble Co.]. [Have recent records.]

***Grais stigmaticus* (Mabille)** 1883. "Grais stigmaticus". 20-IV-1903 (c), 30-VIII-1916 (c), 1-IX-1916 (c-1), 2-IX-1916 (c), 27-IX-1916 (s), 29-X-1916 (c-several), 21-IX-1917 (c-5). [Have recent records.]

***Achlyodes thraso tamenund* (Edwards)** (1807). "Near Grais". 10-31-VII-1904 (c-1) [Kimble Co.], 19-VIII-1907 (c-1), 27-IX-1916 (c-1), 29-X-1916 (c-1). [Should be found occasionally.]

***Systasea pulverulenta* (Felder)** 1869. "S. zampa". 6-IV-1901 (c-1) first I have ever seen at the ranch. 2-VIII-1901 (s), 8-VIII-1901 (c), 2-VI-1902 (s). [Have recent records.]

***Cogia hippalus outis* (Skinner)** 1894. "C. outis". 23-IV-1899 (c-1), 27-IV-1899 (c-3), 10-V-1899 (c-2), 7-IV-1900 (s), 8-IV-1900 (c), 15-IV-1900 (c), 6-IX-1900 (s), 30-III-1901 (s), 4-IV-1902 (s), 18-IV-1902 (s) common now. [Have recent records.]

***Thorybes pylades albosuffusa* Freeman** 1943. "Pylades". 17-IV-1899 (c), 1-IV-1900 (c), 6-IV-1900 (s), 15-IV-1900 (c), 20-III-1901 (c), 7-IV-1902 (c). [Have recent records.]

***Achalarus lyciades* (Geyer)** 1832. "A. lycidas". 19-IV-1901 (c), 1-V-1901 (c), 10-V-1901 (c-2), 28-VI-1901 (c). [No records since 1901, probably no longer in the area.]

***Achalarus casica* (Herrich-Schaffer)** 1869. "Epigena". 24-VIII-1899 (c), 28-VIII-1900 (c), 28-IX-1909 (s-2 or 3 lately), 25-IV-1910 (c-2), 26-IV-1910 (c-2). [No recent records, probably no longer in the area.]

***Achalarus toxeus* (Plötz)** 1882. "A. coyote". 17-IX-1916 (c). [Should be found occasionally.]

***Autochton cellus* (Boisduval & LeConte)** 1834. "C. cellus". 17-IV-1899 (c), 13-IV-1900 (s), 15-IV-1900 (c), 1-IX-1900 (c), 4-IV-1901 (s), 16-IV-1901 (c), 19-IV-1901 (c) commoner than usual, 7-IV-1902 (s). [No recent records, probably no longer in the area.]

***Urbanus proteus* (Linnæus)** 1758. "E. proteus". 26-IX-1900 (c), 13-VI-1902 (c), 10-31-VII-1904 (c-1) [Kimble Co.]. [No recent records but should be found around cultivated beans.]

***Urbanus dorantes* (Stoll)** 1790. "E. rauterbergi". 23-IX-1900 (c), 11-VIII-1907 have seen several specimens lately. [No recent records. Should be found occasionally.]

***Chioides catillus albofasciatus* (Hewitson)** 1867. "E. albofasciatus". 24-VIII-1899 (s), 28-VI-1901 (c), 2-IX-1902 (s), 1-VII-1904 (c-poor specimen), 9-VII-1904 (s), have seen six specimens since the first. 11-VIII-1907 (c) have taken several good specimens lately. [Should be found occasionally.]

***Chioides zilpa* (Butler)** 1874. "like Albofasciatus". 1-IX-1916 (c-3), caught three long-tailed hesperids like *albofasciatus*, 29-X-1916 (c-1). [Should be found rarely.]

***Epargyreus clarus clarus* (Cramer)** [1775]. "E. tityrus". 11-VII-1899 (c), 25-VIII-1899 (c), 11-IV-1901 (s), 9-V-1901 (c), 10-V-1901 (c), 2-VI-1901 (c), 1-VII-104 (c). [Have recent records.]

***Proteides mercurius mercurius* (Fabricius)** 1787. "Eudamus idas". 16-VI-1899 took a large skipper *Eudamus idas*, have never seen it before. [No records since 1899, probably a stray.]

Papilionidae

***Battus philenor philenor* (Linnæus)** 1771. "P. philenor". 30-31-I-1900 (s-during the month), 3-II-1900 (s), 8-III-1900 (s), 2-III-1901 (c), 5-XI-1902 (s), 12-IX-1916 (saw mantis eating one). [Have recent records.]

***Battus polydamas lucayus* (Rothschild & Jordan)** 1906. "P. polydamas". 26-IX-1900 (saw one quite close). [Should be found rarely.]

***Papilio polyxenes asterius* Stoll** 1782. "P. asterius". 19-III-1899 (s), 8-III-1900 (s), 8-IV-1900 (c), 2-III-1901 (c). [Have recent records.]

***Papilio cresphontes cresphontes* Cramer** [1777]. "P. cresphontes". 21-III-1899 (s), 24-III-1900 (s), 1-IV-1901 (s). [Have recent records.]

***Papilio glaucus glaucus* Linnæus** 1758. "P. turnus". 19-III-1899 (s), 9-III-1900 (s), 17-III-1901 (s), 13-27-VII-1902 (c) [Edwards Co.], 29-II-1908 (s). [Probably western distribution limit. Should be found occasionally.]

***Papilio multicaudata* Kirby** 1884. "P. daunus". 29-VIII-1899 (c) Kerrville, 6-IX-1900 (s), 17-VIII-1902 (c), 18-VIII-1902 (c), 5-IX-1908 (saw several times lately), 15-IV-1910 (c-2) it is not as a rule common but it is by no means rare some years, 18-IX-1912 (c). [Have recent records.]

***Papilio troilus* Linnæus** 1758. "P. troilus". 11-III-1900 (s), 14-III-1901 (c-fresh), 17-IX-1903 (found one caught by a green-grey spider). [Western distribution limit. Have recent records.]

Pieridae

***Pieris protodice protodice* Boisduval & LeConte** 1829. "P. protodice". 12-II-1900 (s), 8-III-1900 (s), 4-III-1901 (s), 5-XI-1902 (c). [Have recent records.]

***Ascia monuste phileta* (Fabricius)** 1775. "P. monuste". 11-VIII-1901 (c), 11-VIII-1907 (c) commoner than usual, 14-VIII-1914 (c) fairly common for the last week or two. [Should be found occasionally.]

***Colias eurytheme eurytheme* Boisduval** 1852. "C. eurytheme" also "Ariadne". 21-II-1899 (c-several), 22-II-1899 (s), 3-II-1900 (c), 21-II-1900 (c-5), 8-III-1900

(s), 8-IV-100 (have seen several winter forms lately), 18-I-1901 (c-1) white form, 31-I-1907 (s), 24-I-1909 (s). [Have recent records.]

***Colias cesonia* (Stoll)** 1790. "C. cæsonia". 22-II-1899 (s), 8-III-1900 (s), 18-II-1901 (saw several), 7-III-1909 (c). [Have recent records.]

***Anteos clorinde nivifera* Fruhstorfer** 1907. "Gonepteryx clorinde". 25-IX-1900 (c), 26-IX-1900 (c), 27-IX-1900 (s), 10-VI-1901 (s), 2-IX-1916 (c-1), (s-2), 8-IX-1961 (c), 29-X-1916 (c-2). [Should be found occasionally.]

***Phoebis sennæ eubule* (Linnæus)** 1767. "C. eubule". 8-III-1900 (s), 17-X-1902 (c) quite common this month, 5-XI-1902 (s), 28-I-1903 (s). [Have recent records.]

***Phoebis agarithe maxima* (Neumoegen)** 1891. "C. agarithe". 3-VI-1899 (c-2), 15-VI-1899 (c), 22-VIII-1901 (s), 3-IV-1902 (s), 7-IV-1902 (s), 11-VIII-1907 (fairly common, hard to get perfect), 23-VIII-1916 (c) very common, 29-X-1916 (has been very common). [Have recent records.]

***Kricogonia lyside* (Godart)** 1819. "K. lyside". 10-V-1899 (c-5), 12-V-1899 (common), 12-IV-1900 (s), 7-XI-1900 (scarce), 9-IV-1902 (s) quite a number, all flying in southwesterly direction singly; wind south, 10-IV-1902 (c), 14-IV-1902 (of the hundreds that crossed the road as I was riding to town Saturday, everyone of them was going in a southerly direction), 30-IV-1902 (out fresh), 18-VI-1902 (c), 27-V-1903 (c-fresh), 29-VIII-1907 (very common), 1-VI-1918 (swarms, 3 or 4 forms, were passing the ranch today from soon after noon till about 4 p.m., all going East. Lena Denton phoned from the Masterson ranch to say the same thing was happening there. There was a constant stream of them crossing the trail. 22-VI-1918 (still numerous), 11-IV-1919 (s) few, 12-IV-1919 (going south), 13-IV-1919 (still going south). [Have recent records.]

***Eurema mexicana* (Boisduval)** 1836. "E. mexicana". 30-IV-1900 (c) numerous. [Have recent records.]

***Eurema lisa* Boisduval & LeConte** 1829. "E. lisa". 21-I-1901 (s), 5-XI-1902 (s), 26-I-1909 (c). [Have recent records.]

***Eurema nicippe* (Cramer)** [1780]. "Nicippe". 21-I-1901 (s), 5-XI-1902 (s). [Have recent records.]

***Nathalis iole* Boisduval** 1836. "N. iole". 22-II-1899 (s), 30-31-I-1900 (s) this month, 8-III-1900 (s), 18-I-1901 (c), 21-I-1901 (c), 5-XI-1902 (c), 24-I-1909 (s). [Have recent records.]

***Anthocharis midea midea* (Hübner)** [1809]. "Genutia". 15-IV-1900 (c), 11-IV-1901 (c), 7-IV-1902 (c), 16-IV-1902 (c), 1-III-1909 (s), 7-III-1909 (c). [Have recent records.]

Riodinidae

***Calephelis australis* Edwards** 1877. "C. australis". 1-IX-1900 (c), 18-IV-1901 (c), 13-27-VII-1902 (c) [Edwards Co.]. [Have recent records.]

***Calephelis rawsoni* McAlpine** 1939. Not mentioned by Lacey. *Holotype* male and one *paratype* male collected by Lacey, July 1908 Kerrville, Texas and just Kerrville, Texas respectively. It is unlikely that Lacey actually collected these specimens at Kerrville. The authors have reared this species from vicinity of Lacey's old ranch but have been unable to locate suitable habitats in or very near Kerrville.

Lycaenidae

***Harkenclenus titus watsoni* (Barnes & Benjamin)** 1926. "T. titus". 11-VI-1900 (c), 21-VI-1900 (c) on button willows [*Cephalanthus occidentalis*] which are just out, 17-VI-1901 (c-2), 25-V-1902 (c-1♀). [No recent records but should be found occasionally.]

***Satyrium calanus falacer* (Godart)** [1824]. "T. calanus". 12-V-1899 (c), 17-V-

1899 (c-20) all fresh, 15-V-1900 (c), 14-V-1901 (c), 18-V-1901 (c) about 20, 14-V-1902 (c) first few I get are always darker than the later ones, 21-V-1902 (common), 24-V-1903 (c). [Have recent records.]

***Calycopis beon* (Stoll)** 1782. "T. cecrops". 27-III-1900 (s), 2-III-1901 (c), 13-VI-1902 (s), 18-VI-1902 (c). [Have recent records.]

***Tmolus azia* (Hewitson)** 1873. Not listed in Lacey's field notes. Recorded by Barnes & McDunnough (1913). Collected by Lacey (1 ♀), Paint Creek, Edwards Co. Texas. No date given. According to Lacey's field notes, he visited Paint Creek 15 July 1898, 23 November to 6 December 1916, and 19–26 July 1919; the last two dates are ruled out for obvious reasons, leaving 15 July 1898 most likely date of capture. [A stray.]

***Callophrys henrici solatus* Cook & Watson** 1909. "I. irus". 20-III-1899 (c-6), 21-III-1899 (c-4), 8-III-1900 (c), 13-III-1901 (c-3), 15-III-1901 (c) several, 16-III-1903 (c). [Single brooded. Have recent records.]

***Callophrys gryneus castalis* (Edwards)** 1871. "T. damon". 13-III-1899 (c), 21-III-1899 (c-2) [Kimble Co.], 26-VII—5-VIII-1899 (c) several very dark, 9-III-1900 (s), 2-III-1901 (c), 30-IV-1902 (c). [Have recent records.]

***Atlides halesus corcorani* Clench** 1942. "A. halesus". 15-VI-1899 (c-2), 25-VIII-1899 (c), 27-III-1900 (s), 1-IX-1900 (c), 21-VIII-1901 (s), 13-VI-1902 (s), 18-VI-1902 (c), 7-III-1909 (c). [Have recent records.]

***Euristrymon ontario autolycus* (Edwards)** 1871. "Autolycus". 15-V-1900 (c), 17-V-1901 (c) 40 good specimens, 21-V-1902 (common), 24-V-1903 (c). [Have recent records.]

***Panthiades m-album* (Boisduval & LeConte)** [1833]. "T. m-album". 29-VIII-1907 (c) first I have ever seen. [No records since 1907. Probably western distribution limit.]

***Strymon melinus franki* Field** 1938. "T. melinus". 14-III-1900 (c), 24-V-1903 (c) on milkweed blossoms. [Have recent records.]

***Strymon columella istapa* (Reakirt)** [1867]. "T. columella". 25-VI-1902 (c) first I have seen here. [Should be found occasionally. Have one recent record.]

***Strymon alea* (Godman & Salvin)** [1887]. *Callicista laceyi* Barnes & McDunnough 1910. Not mentioned in Lacey's field notes. *C. laceyi* was described from a female collected by Lacey in July 1909 at Del Rio, Texas. Lacey left Kerrville 15 July 1909 for the Devils River on a fishing trip. He stayed until 31 July. It is unlikely that he passed through Del Rio which would have been considerably out of his way. The most likely place of capture was on the Devils River north of Del Rio in Val Verde Co.

***Leptotes marina* (Reakirt)** 1868. "L. marina". 10-V-1899 (c-1). [Should be found there occasionally.]

***Hemiargus ceraunus zachœina* (Butler & Druce)** 1872. "L. gyas". 5-XI-1902 (c-1), like *isola* without black spots beneath upper wing, 29-X-1916 (fairly common). [Have recent records.]

***Hemiargus isola alce* (Edwards)** 1871. "Isola". 8-IV-1900 (s), 5-XI-1902 (c), 10-II-1903 (c). [Have recent records.]

***Everes comyntas comyntas* (Godart)** [1824]. "E. comyntas". 27-IV-1899 (c-1 ♀), 9-VIII-1899 (c), 24-III-1900 (s), 21-VI-1900 (c), 30-III-1901 (c) have been out a few days. [No recent records, but should be found occasionally.]

Libytheidae

***Libytheana bachmanii larvata* (Strecker)** [1878]. "L. bachmanii". 7-XI-1900 (scarce), 24-IV-1901 (c), 5-XI-1902 (c), 28-I-1903 (s), 10-II-1903 (s) out every warm day throughout the winter, 13-VIII-1916 (swarming), 20-VIII-1916 migrating in countless thousands all going southeast, 21-VIII-1916 still going east in less numbers, 12-IX-1916 hundreds of thousands on the verbesina weeds [*Verbesina*

virginica L.] last few days, 25-IX-1916 still going southeast, 5-X-1916 large flight went by the ranch, 8-X-1916 still migrating, 16-X-1916 few disreputable specimens going east, 29-X-1916 swarming and migrating. [Have recent records.]

***Libytheana carinenta mexicana* Michener** 1943. "Carinenta". 5-XI-1902 (c). [Probably a stray.]

Nymphalidae

***Anaea andria andria* Scudder** 1875. "A. andria". 18-III-1900 (c), 13-III-1901 (s), 7-III-1909 (c), 4-I-1917 (c). [Have recent records.]

***Anaea aidea morrisonii* (Edwards)** 1883. "A. morrisonii". 7-XI-1900 (c). [Should be found rarely.]

***Mestra amymone* (Ménétriés)** 1857. "C. amymone". 8-IX-1898 (c-1), 27-IX-1898 (c-1), 18-VI-1900 (s), 22-VI-1900 (s), 7-VII-1900 (c) [Kimble Co.], 25-VI-1902 (c). [Have recent records.]

***Marpesia chiron* (Fabricius)** 1775. "Timetes chiron". 28-VIII-1899 (c-1) have been looking for him every day since I saw him on the 24th, 3-VIII-1902 (s), 14-VII-1905 (s-worn), 11-VIII-1907 (c-1) saw another, 25-VIII-1907 (s) third seen this year, 1-IX-1916 (s-1). [Should be found rarely.]

***Marpesia petreus* (Cramer)** [1776]. "T. peleus". 14-VIII-1907 (c-2), 29-VIII-1907 (c-1) a good specimen, third taken and fourth seen this year. [Should be found rarely.]

***Limenitis astyanax astyanax* (Fabricius)** 1775. "Ursula". 30-IV-1902 (c) they have been out for about a week. [Have recent records.]

***Limenitis archippus watsoni* (dos Passos)** 1938. "L. disippus" [Possibly hybrid]. 25-VI-1899 (c) at San Antonio [Bexar Co. Texas], 14-VII-1905 (c-1) fresh, it is not at all common here. [Have recent records.]

***Limenitis bredowii eulalia* (Doubleday)** [1848]. "H. californica". 22-VIII-1900 (s-1) saw another about two years ago, 29-IX-1900 (s-2), 3-XI-1900 (s-1), 4-XI-1900 (s), 13-27-VII-1902 (c) [Edwards Co.], 8-VIII-1903 (s), 17-IX-1903 (c), 18-IX-1903 (s), 29-IX-1903 (s-2) fresh, 30-IX-1903 (s), 15-IV-1904 (s-3), 18-VI-1904 (c), 9-VII-1904 (s), 29-VIII-1907 (s) fresh, 12-IV-1910 (s-several) fresh, 3-IV-1916 (s) fresh, 29-X-1916 (fairly common). [Occasionally becomes temporary resident. Have recent records.]

Metamorpha steneles biplagiata (Fruhstorfer) 1907. "V. steneles". 26-27-VI-1904, saw what I suppose was *V. steneles* but the ground color was yellowish instead of white; tried hard to get him but failed. [Should stray into area rarely.]

***Vanessa atalanta* (Linnæus)** 1758. "Atalanta". 30-I-1900 saw this month, 4-II-1900 (s), 8-III-1900 (s), 21-I-1901 (s), 5-IX-1902 (s), 24-I-1909 (s), 4-I-1917 (s). [Have recent records.]

***Vanessa virginiensis* (Drury)** [1773]. "Huntera". 30-I-1900 saw this month, 8-III-1900 (s), 21-I-1901 (s), 17-II-1901 (s) often very small in winter and early spring [attributed to scarcity of larval food plant], 5-XI-1902 (c). [Have recent records.]

***Vanessa cardui* (Linnæus)** 1758. "P. cardui". 8-III-1900 (s), 21-VIII-1901 (c) common, 16-XII-1902 (s). [Have recent records.]

***Junonia cœnia cœnia* (Hübner)** [1822]. "J. cœnia". 20-III-1900 (c), 13-IV-1900 (s), 5-XI-1902 (s), 26-I-1909 (c). [Have recent records.]

***Nymphalis antiopa lintnerii* (Fitch)** 1856. "V. antiopa". 25-II-1900 (s) worn, 17-V-1900 (s), 31-V-1900 (c), 18-II-1901 (s), 2-III-1901 (s), 8-V-1902 (c), 27-V-1903 (s-2), 28-V-1903 (c-1), 31-V-1903 (c-1), 22-II-1907 (s) more than ever before, 7-V-1911 (c-several); not common at the ranch. Saw none in 1899 and only two in 1898. [Should be found occasionally.]

***Polygonia interrogationis* (Fabricius)** 1798. "C. interrogationis". 22-II-1899

(s), 4-II-1900 (s), 30-IV-1900 (c) numerous, fresh, 30-IV-1902 (c). [Have recent records.]

Polygonia comma **(Harris)** 1842. "P. comma". 15-IV-1900 (s), 11-IV-1901 (c). [No records since 1901. Probably no longer present.]

Chlosyne janais **(Drury)** 1782. "Synchloe janais". 27-VI-1899 (c) [Bandera Co.], 22-VII-1908 (s) in garden. [Should stray into the area occasionally.]

Chlosyne lacinia adjutrix **Scudder** 1875. "S. lacinia". 27-VI-1899 (c) [Bandera Co.], 13-IV-1900 (s), 5-IV-1901 (c), 15-IV-1902 (s), 16-IV-1902 (c), 5-XI-1902 (c), 5-XI-1902 (s), 11-VIII-1903 (1-*ex larva*; larva found on white ragweed [*Parthenium hysterophorus* L.], 31-VIII-1903 (1-*ex* larva). [Have recent records.]

Chlosyne endeis **(Godman & Salvin)** 1894. Not listed in Lacey's field notes. Recorded by Barnes & McDunnough (1913). Collected by Lacey (1♂, 1♀); ♂ marked "Texas," the ♀ May 1902, Edwards Co., much worn. [Strays].

Phyciodes texana texana **(Edwards)** 1863. "E. texana". 21-I-1901 (s), 2-III-1901 (s), 30-IV-1902 (s) fresh, 25-VI-1902 (c), 20-II-1909 (c). [Have recent records.]

Chlosyne nycteis nycteis **(Doubleday)** [1847]. "P. nycteis". 12-IV-1900 (s), 30-III-1901 (s), 10-IV-1902 (s), 16-IV-1902 (c). [Have recent records.]

Chlosyne gorgone carlota **(Reakirt)** 1866. "Ph. ismeria". 19-IV-1899 (c). [No recent records, but should be present.]

Phyciodes tharos tharos **(Drury)** [1773]. "Ph. tharos". 13-III-1900 (s), 18-III-1900 (s), 7-III-1909 (c). [Have recent records.]

Phyciodes phaon **(Edwards)** 1864. "Phaon". 18-III-1900 (c), 30-III-1901 (c), 5-XI-1902 (s), 7-III-1909 (c). [Have recent records.]

Phyciodes vesta **(Edwards)** 1869. "Ph. vesta". 21-III-1899 (s), 18-III-1900 (c), 18-III-1901 (s), 25-IV-1901 (c), 7-IV-1902 (c), 10-IV-1902 (c), 5-XI-1902 (c), 24-I-1909 (s). [Have recent records.]

Thessalia theona bollii **(Edwards)** [1878]. "M. bollii". 25-V-1900 (c) first I have ever seen, 28-V-1900 (c-1), 21-VI-1900 (c-3), 6-IX-1900 (s), 19-V-1908 first I have seen here for years, 5-IX-1908 (c) fairly common on the hill, 7-IX-1908 (c) more on the hill. [Have recent records.]

Dymasia dymas **(Edwards)** 1864. "M. dymas". 25-26-VI-1899 (c) San Antonio [Bexar Co.]. [Have recent records, but urbanization is rapidly destroying habitats.]

Texola elada ulrica **(Edwards)** 1877. "M. elada". 15-26-VII-1898 took good series [Edwards Co.], 25-30-VII-1901 (c) [Kimble Co.], 8-VIII-1901 (c), 30-IV-1902 (c). [Have recent records.]

Poladryas minuta minuta **(Edwards)** 1861. "M. arachne". 15-VII-1898 (c-2) [Edwards Co.], 27-IX-1898 (c-18) near [ranch] gate, 21-VI-1900 (c), 14-IV-1901 (s), 20-IV-1901 (c-45), 21-VIII-1901 (s), 22-IV-1902 (s) several, 23-IV-1902 (c), 30-IV-1902 (common), 9-VI-1902 (s) many on Kerrville road, 13-VI-1902 (fairly common), 21-VIII-1904 fresh brood out, 7-IX-1908 (c-2), 26-I-1909 (s) not seen generally until April, 15-VIII-1909 (c) several, 12-IV-1910 (s), 14-II-1911 (s) along Turtle Creek road. [No records since 1911. Habitats probably destroyed by over grazing of sheep and goats.]

Euptoieta claudia **(Cramer)** [1776]. "E. claudia". 31-I-1900 (s) this month, 4-II-1900 (s), 21-II-1900 (c), 7-XI-1900 (c), 17-II-1901 (s), 5-XI-1902 (s). [Have recent records.]

Euptoieta hegesia hoffmanni **Comstock** 1944. "E. hegesia". 15-VIII-1909 saw fine fresh *E. hegesia* but failed to get it. [Should stray into the area rarely.]

Heliconius charitonius vazquezæ **Comstock & Brown** 1950. "Heliconius charitonius." 26-VII-1898, one of the Miller boys caught it by hand in Kerrville and brought it to Palmer's place. I have not seen it here before. 19-VII-1908, saw one in the garden but couldn't get it. [Migrant. Should be found there occasionally.]

Dryas julia moderata **(Stichel)** 1907. "Colænis julia". 7-X-1900, Jim Taylor

took one last month and brought it to me to identify. 6-X-1906 (s-2), 11-VIII-1907 (c-1) at the ranch; better than I got in Mexico. 14-VIII-1907 (c-1) saw three others. [Migrant. Should be found occasionally.]

***Agraulis vanillae incarnata* (Riley)** 1926. "A. vanillæ". 24-IV-1900 (s) fresh, 2-II-1901 one settled three times on the stem of my pipe as I was having a smoke near the little dam, 5-XI-1902 (s) fresh. [Have recent records.]

Danaidae

***Danaus plexippus plexippus* (Linnæus)** 1758. "D. archippus". 28-X-1882 crowds going south, 23-X-1892 were passing over all day, 25-III-1900 common, weary looking, 17-V-1900 (s) fresh, 13-III-1901 (s) worn, 30-IV-1902 (c) fresh, 5-XI-1902 (s) fresh, 27-V-1903 (s-1) fresh, 19-X-1904 in swarms, 29-II-1908 (s) fresh, 8-X-1916 gathering about the willows and pecans, 10-X-1916 going south in hundreds, 31-III-1917 going north, not in the big bunches that go south in the fall, 5-X-1918 for the last week they have been swarming in the pecan.

***Danaus gilippus strigosus* (Bates)** 1864. "Strigosus". 21-I-1901 (s), 13-III-1901 (s), 5-XI-1902 (s), 24-I-1909 (s). [Have recent records.]

Satyridae

***Euptychia hermes sosybius* (Fabricius)** 1793. "N. sosybius". 11-VI-1900 (c), 1-VII-1904 (s). [Should be found occasionally.]

***Euptychia cymela cymela* (Cramer)** [1777]. "Eurytus". 15-V-1900 (c). [Possibly western distributional limit. Have recent records.]

***Euptychia rubricata* Edwards** [1871]. "N. rubricata". 5-V-1900 (s), 28-VIII-1900 (c), 6-IX-1900 (c), 4-III-1901 (s-1), 6-IV-1901 (c), 16-IV-1901 (c), 8-V-1902 (c). [Have recent records.]

***Cercyonis pegala texana* (Edwards)** 1880. "S. texana". 21-VI-1900 (c), 7-19-VII-1900 (c) [Kimble Co.], 16-VI-1901 (s) several, 9-VI-1902 (s). [Have recent records.]

Sphingidae

***Manduca sexta* (Johanssen)** 1763. "Carolina". 12-IX-1916 yesterday I took a large Carolina sphinx from a mantis. [Have recent records.]

***Sphinx eremitoides* Strecker** 1874. "H. eremitoides". 12-IX-1916 a mantis was eating an *H. eremitoides*, 13-IX-1918 yesterday I noticed 3 or 4 *H. eremitoides* resting on posts while fixing fence. This morning I went around with a poison jar and gathered in about 20. Their color matched the cedar posts exactly. 14-IX-1918 (c-6), 22-IV-1919 many on fence posts, 23-IV-1919 more, quite a bunch of them. [Have recent records, but never found common.]

***Hemaris thysbe* (Fabricius)** 1775. "Thysbe". 10-III-1900 (c), 25-III-1900 watched female laying its eggs on flower buds of black haw [*Crataegus tracyi* Ashe]. Last year I found the caterpillars of this moth feeding on honeysuckle [*Lonicera albiflora* T. & G.] 13-III-1901 (c-1). [Should be found occasionally.]

***Hemaris diffinis* (Boisduval)** 1836. "H. axillaris". 10-III-1900 (c). [Should be found occasionally.]

***Amphion nessus* (Cramer)** 1777. "Amphion nessus" 28-III-1900 (c). [Should be found occasionally.]

***Xylophanes tersa* (Linnæus)** 1771. 7-XI-1896 on Nueces [River] [Uvalde Co.] picked up a sphinx larva with false eyes on it like the elephant hawk at home [*Deilephila elpenor* L.] [Have recent records.]

***Hyles lineata* (Fabricius)** 1775. "C. lineata". 10-III-1900 (c-2), 19-V-1908 screech owl feeding her young Sphinx moth (*lineata*). [Have recent records.]

Saturniidae

***Hyalophora cecropia* (Linnæus)** 1758. "Cecropia". 6-IV-1900 (1) *ex pupa*, another 3 or 4 days ago. 3-IV-1901 (1) *ex pupa*, 12-V-1901 (1) *ex pupa*, 24-V-1903 (1) *ex pupa*. [Should be found occasionally.]

***Actias luna* (Linnæus)** 1758. "Luna". 6-III-1908 yesterday I saw a beautiful fresh *luna* moth. [Have recent records.]

***Antheraea polyphemus* (Cramer)** 1775. "T. polyphemus". 11-VI-1902 on the first of the month Rawson got me a female *T. polyphemus*; she laid a lot of eggs which I brought home and the larvae were hatched this morning. 6-III-1918 (c). [Have recent records.]

***Hemileuca maia* (Drury)** 1773. "Hemileuca maia". 4-XI-1900 (c-1) first this year, 11-XI-1902 (1) *ex larva*, 18-XI-1902 a female hatched from one of my pupae. I took it outside with a bit of mosquito curtain over the box. It was immediately surrounded by males. All the males came up wind to the box and when they over ran the scent, circled back to it like a pack of hounds. 31-X-1903 (s), 23-X-1904 (c), 11-XI-1912 (s) first this season. [Have recent records.]

***Hemileuca grotei* Grote & Robinson** 1868. "H. grotei". 5-XI-1902 (c), 7-XI-1902 (1♀) *ex larva*, 9-X-1904 (1♀) *ex larva*. [Have recent records.]

***Eacles imperialis* (Drury)** 1770. "Eacles imperialis". 26-VIII-1901 (c). [No recent records. Probably western distribution limit.]

Amatidae

***Horama texana* Grote** 1867. "Horama texana". 1-IX-1916 (c) first I have seen here, 2-IX-1916 (c). [No recent records but should be found occasionally.]

Arctiidae

***Apantesis arge* (Drury)** 1770. "Arge". 7-XI-1900 (c), 26-II-1901 watched *arge* deposit eggs on a dead grass stem. [Have recent records.]

***Hyphantria cunea* (Drury)** 1770. "H. cunea". 16-X-1900 caterpillars have stripped most of the pecans and walnuts of their leaves; ranchers are busy attending to the caterpillars. 6-X-1909 worse than ever, the caterpillars get into everything and in some places are all over the ground. 10-X-1916 webworms (*H. cunea*) very numerous this year. [Have recent records.]

Noctuidae

***Pseudaletia unipuncta* (Haworth)** 1809. "L. unipuncta". 9-X-1904 very common a week or two ago, 26-XI-1904 numerous caterpillars this year. [Have recent records.]

***Lithophane laceyi* (Barnes & McDunnough)** 1910. Not mentioned by Lacey in his field notes. Described from specimens collected by Lacey. Should be there.

***Spodoptera frugiperda* (Smith)** 1797. "L. frugiperda". 9-X-1904 very common a week or two ago, 26-XI-1904 same as above. [Have no recent records.]

***Catocala consors* (Smith)** 1797. "Consors". 25-V-1902 (c) out now. [Have recent records.]

***Catocala junctura* Walker** 1857. "Junctura". 25-V-1902 (c). [Have recent records.]

***Catocala frederici* Grote** 1872. "Catocala frederici". 31-V-1903 (c) at night. This is the fourth of this rare species that I have taken. [Should be found rarely.]

***Catocala ultronia* (Hübner)** 1823. "Ultronia". 25-V-1902 (c). [Should be taken rarely.]

***Catocala similis* Edwards** 1864. "Similis". 25-V-1902 (c). [Should be found rarely.]

***Catocala micronympha* Guenée** 1852. "Micronympha". 25-V-1902 (c). [Have recent records.]

***Catocala amica* (Hübner)** 1818. "Amica". 25-V-1902 (c). [Have recent records.]

***Alabama argillacea* (Hübner)** 1823. "A. argillacea". 9-X-1904 swarms everywhere, 26-XI-1904 numerous. [No recent records but should be found regularly.]

Notodontidae

***Datana ministra* (Drury)** 1773. "Caterpillars". 27-VI-1899 the pecan trees on the Medina [River] [Bandera Co.] are completely stripped of their leaves by caterpillars, something like those of our buff-tip moth [*Phalera bucephala* L.] [Have recent records.]

Lasiocampidae

***Malacosoma disstria* Hübner** 1820. "M. disstria". 23-IV-1900 last Friday and Saturday the train was delayed for half an hour in the neighborhood of Boerne, Texas [Kendall Co.] by the quantity of caterpillars on the rails that prevented the wheels from getting a grip on them. These caterpillars are completely stripping the oak trees. [This species was very abundant during 1959–1964 throughout central Texas. It has since been under control, apparently through natural biological means.]

Megalopygidae

***Lagoa laceyi* Barnes & McDunnough** 1910. Not mentioned by Lacey. Described from specimens collected by Lacey. No recent records, but it should be found there rarely.

Acknowledgment

This article is dedicated to the memory of our very dear friend and fellow Lepidopterist, Mrs. Ellen Schulz Quillin who died suddenly at her home in San Antonio, Texas 6 May 1970. Mrs. Quillin was founder of the Witte Memorial Museum and Director for thirty-seven years, and Director Emeritus until her death. She was a noted botanical author and lecturer. Without her foresight in acquiring the hand scribed field notes of Howard George Lacey, these data could not now be made available to the Lepidopterists' community.

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A REVISION OF *SPEYERIA NOKOMIS* (NYMPHALIDAE)[1]

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It is proposed that *Speyeria nokomis nitocris* (Edwards) be elevated from the synonymy as placed by dos Passos (1964), to subspecific rank for the reasons which are delineated in the paragraphs below.

In an earlier work (dos Passos and Grey 1947), *Speyeria nokomis nitocris* was treated as a valid subspecific taxon, but later (1964), dos Passos treated this taxon as synonymous with *S. nokomis nokomis* (Edwards). For the past several years, we have made a study of this insect in Colorado (M. F.) and in Arizona and New Mexico (C. D. F.). The Colorado insect, *S. nokomis nokomis* is quite distinct in habitat and fascia from the Arizona-New Mexico insect, *S. nokomis nitocris*.

Speyeria nokomis nokomis (Edwards)

Original Description: "Descriptions of certain species of diurnal Lepidoptera found within the limits of the United States and British America." No. 3. Proc. Acad. Nat. Sci. Philadelphia 14: 221 (1863). Figured by Edwards, B. N. A. pl. Argynnis 4 (1868).

Type Locality: This was fixed by dos Passos and Grey (1947) as Mount Sneffels, Ouray Co., Colorado. This location has been questioned by Brown (1957b, p. 335) and does not appear consistent with presently known habitats for *n. nokomis*. The neotype male (AMNH) bears the label "Oslar Sneffels Mts Ouray Co Col Aug 9000 Ft.," "A. nokomis." and "Ex Coll. Wm. C. Wood Acc. 36915."

Discussion: In the plate which accompanies this paper, three subspecies of *Speyeria nokomis* are figured. Dorsally the males are similar

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but distinct differences are evident on the ventral surfaces. In *S. n. nokomis*, the discal area of the hind wing is a pale cinnamon brown. The silver spots are large, brilliant, and moderately edged with black. The species as a whole is strongly dimorphic (excepting *n. werona*) and the females dorsally tend almost to black basally. In *n. nokomis*, dorsally the females show a blue-green overscaling in the dark areas with a light buff submarginal band. On the primary, the band shows a yellow-orange flush; on the secondary the flush is bluish. Ventrally, the females are similar to the males as far as the primaries are concerned, except that the colors are more intense and the ground color is a darker red. On the secondary, the submarginal band is a light buff and the ground color of the discal area is buff overscaled with a greenish-black dusting. Females from the Paradox Valley colony in Colorado tend to be more blue dorsally than specimens from other localities.

This insect is currently known from several locations in Colorado, from Uintah Co. in eastern Utah, and in a blend with *n. apacheana* from more westerly areas of Utah. The Colorado locations are Unaweep Canyon, Mesa Co., 6000′ and Paradox Valley, Montrose Co., 5200′. The Colorado habitats are nearly neutral seep areas where there is a constant flow of water and are surrounded by willow thickets. The violets which serve as the larval foodplant grow in the understory of the seeps and are found only sparsely in the thickets. The surrounding region, except in the vicinity of other seeps and washes is relatively arid. The sites of both colonies are unusual with respect to their geology. The usual rock formation in this portion of Colorado is Mancos shale. The Unaweep Canyon seep emerges along a spring line in granite and flows over what appears to be stream alluvium. The canyon is unusual in that it is mainly composed of granite. The Paradox Valley colony is in a blowsand area. The Uintah Co., Utah area is a rather unrewarding looking meadow, but with the necessary prerequisites of willow, violets, and a constant flow of water. The presence of willow is probably only incidental to the presence of *nokomis*. Both willows and violets are frequently found in the same location in arid regions.

There is one additional recent record of *S. nokomis* from Colorado. This is a worn female taken by Scott Ellis at Rogers Mesa Delta Co., 5850′, 26 August 1958. The source of this specimen has not yet been determined, although it perhaps came from an undiscovered Colorado colony.

Dos Passos and Grey (1947) fixed the type locality for *S. nokomis nokomis* as Mount Sneffels, Ouray Co., Colorado. We feel that we must take exception to this fixation for several reasons. Collecting in recent

years in this area (Brown, *in litt.*) has failed to turn up this butterfly. The ecology of the fixed type locality is not consistent with currently known collection areas. Furthermore the neotype does not fit the original description (Brown, 1965). There is also a disparity in dates. Dos Passos (1964) indicates an 1862 ("1861–3") date for the Edwards publication of the description of *n. nokomis*. If this is the correct date, it would not seem possible for the specimens to have come from Ouray Co., as the first whites to enter this area came in 1871. Oslar is known to have been quite inaccurate in his data. As Brown has mentioned (1965), the Macomb Expedition entered the area west of Paradox Valley in 1859 (Macomb and Newberry 1876). It is possible that the material ascribed to Edwards 1862 was actually collected on this expedition. Brown placed the probable type locality for *S. nokomis nokomis* (Edwards) (and not for the neotype *S. nokomis nokomis* dos Passos and Grey) as Ojo Verde, San Juan Co., Utah. The location Ojo Verde is mentioned in the Macomb/Newberry report. The topographical coordinates are given in the report as lat. 38° 14′ 50″ and long. 109° 26′ 40″. Present United States Coast and Geodetic Survey maps do not show Ojo Verde, but the coordinates would indicate it to be in the vicinity of Hatch Wash. In August, 1969, the senior author attempted to locate this site. He was unsuccessful as that portion of Utah is now posted as an impact area for test missiles launched from Green River, Utah. The warning notices and travel directions were sufficiently ambiguous that he did not wish to risk entry into the area.

The comments in the Macomb/Newberry report would appear to indicate a possible habitat for *n. nokomis*. Macomb and his associates camped at Ojo Verde in mid-August and would thus have been there at the correct time of the year for the insect's flight. Of the area, the following comments are made: "The Ojo Verde is a copious spring in a cañon cut out of the red sandstone, ten miles west of La Teneja. The surrounding country is very sterile, sparsely set with sage bushes and small cedars, but about the spring the bottom of the cañon is covered with the greenest and most luxuriant grass."

It would appear then that the type locality for *S. nokomis nokomis* (Edwards) is most probably somewhere in eastern Utah, and not in Ouray Co., Colorado, although L. P. Grey now favors the Rio Hondo area in Lincoln Co., New Mexico.

There also exists a record of a single male and two females of *S. n. nokomis* taken September 15, 1877 by Lt. C. A. H. McCauley at the crossing of the Lower Rio Florida, La Plata, Co., Colorado 6500–7000′ some

twenty miles east of Durango. These specimens are now part of the Strecker Collection at the Chicago Natural History Museum. The male was apparently misidentified at one point in time and appears to be *S. cybele carpenteri* (Edwards) (see Brown 1957a). It was originally recorded in the McCauley report (1879) as *Argynnis cybele*. The female records were checked by L. P. Grey and one is figured in the report (Plate I).

The flight span of *S. n. nokomis* is generally during the first three weeks in August, although it has been taken from mid-July (Unaweep Canyon) into September.

Speyeria nokomis nitocris (Edwards)

Original Description: "Description of new species of diurnal Lepidoptera found in North America." Trans. Amer. Ent. Soc. 5: 15–16 (1874). Figured by Edwards, B. N. A. 3: [91–92], Argynnis I; Holland, B. B., p. 85, pl. 13. (type).

Type Locality: White Mountains, Arizona. Based upon the discussion in Brown (1965), and the study by the senior author of the distribution of *nokomis* in Arizona, the type locality is probably east of Ft. Apache, along the East Fork of the White River, Apache Co., Arizona. The lectotype (designated by dos Passos and Grey 1947) (CM) bears the label "Nitocris ♂ W. Mtns. Ariz. type" and is the specimen figured by Holland.

Discussion: The accompanying plate clearly shows the differences between *n. nokomis* and *n. nitocris*. Generally the colors are much more intense in *n. nitocris*. In the males, ventrally, the discal area of the secondary is a deep cinnamon brown, the silver spots are quite brilliant and heavily margined with black scales. The submarginal band is darker than in *n. nokomis* and shows an orange flush over the lighter buff ground color. In the females, dorsally, the dark colored areas are more extensive than in *n. nokomis* and the blue-green overscaling is more prominent. Ventrally, the discal area of the secondary has a cinnamon ground color which is heavily overscaled with velvety black. The submarginal band is yellow-buff but overscaled with dark scales.

The habitat of *S. n. nitocris* lies in lush Canadian Zone meadows or along the mountain streams which feed such meadows. The adults show a preference for feeding upon red thistles of various species. *S. nokomis nitocris* generally flies at higher elevations that does *S. n. nokomis*. It has been taken from 5400′ to 8500′ and appears to be more common at higher elevations. It has been recorded from Arizona: Gila, Coconino, Greenlee, Navajo, Apache Cos.; from New Mexico: Catron, Valencia, San Miguel, Taos Cos. *S. n. nitocris* is found in the region of the Mogollon Rim and White Mountain country in Arizona, and in the extension of this terrain into New Mexico (Mogollon Mountains and eastward). It then

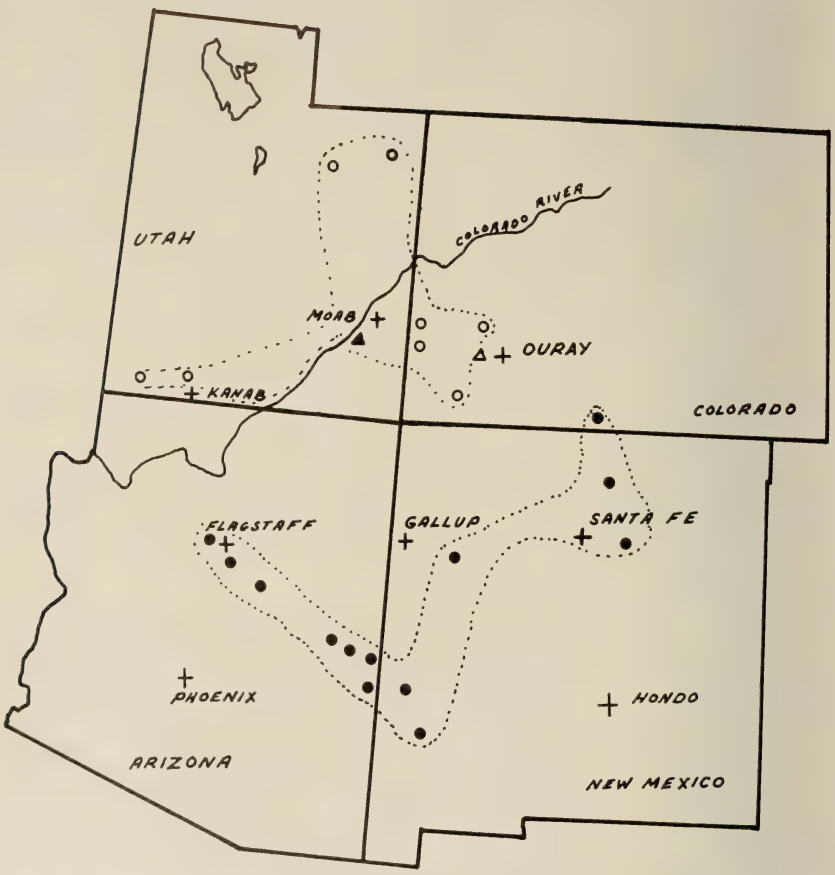


Fig. 1. Probable distribution for S. *nokomis*. Solid dots indicate S. *nokomis nitocris*; open dots indicate S. *nokomis nokomis*. Not all collection sites are shown. The dotted line which encloses each series of dots indicates the probable range of the given subspecies where suitable habitats exist. Mt. Sneffels is represented by the open triangle and Ojo Verde by the solid triangle.

occurs in pockets at various other locations in New Mexico. The flight period extends from mid-August into early September.

Of the two subspecies, *nitocris* is the more common. Both are quite local, but *nitocris* has been taken in numerous localities and is sometimes found in high concentration. In both subspecies the males appear to outnumber the females by a ratio of more than 5:1. The females appear less active than the males and keep to areas with dense vegetation. In *nitocris*, the males appear as soon as the dew starts to dry off in the

morning and they may be seen feeding or patrolling their territories. The females appear more toward noon and except when feeding, are generally flushed from the tall grass and willows which border the streams associated with their habitat. Mating behavior has been described by Ferris (1969).

It is interesting to note that as one examines western populations of *S. nokomis* through Utah and into California, the ratio of the sexes becomes nearly equal.

From a somewhat limited study, it would appear that both subspecies appear in strength in any given colony on an alternate year basis.

For comparison, also illustrated in the plate are specimens of *S. nokomis apacheana* (Skinner) from California. Ventrally these are quite distinct from the Rocky Mountain Region-Northern Arizona-New Mexico material. In the males the discal area is almost the same color as the submarginal band. In the females, the discal area is concolorous with the submarginal band, but is overscaled with greenish-black.

We interpret the range of *S. nokomis nokomis* as being restricted to southwestern Colorado, and to Uintah and San Juan Cos., Utah. It would appear from preliminary studies that *n. nokomis* and *n. apacheana* intergrade in Utah. An interesting note on the blend zone situation was presented by Swisher and Morrison (1969). They collected *nokomis* from California to Colorado. Based upon a somewhat limited number of specimens, they found *n. apacheana* to be the only form in California. In Washington Co., Utah (SW Utah at Leeds), they found 24% intermediate between *n. apacheana* and *n. nokomis*. Collecting at Glendale, Kane Co. (40 miles east of Leeds) yielded 17% intermediates and 15% referable to *n. nokomis*. In northeastern Utah at Vernal, Uintah Co., they found 20% intermediate and 44% were referable to *nokomis*. Colorado specimens (Montrose Co.) were all *n. nokomis*. The remaining percentage figures at each site apply to *n. apacheana*. The sex ratio, males to females, are reported as 3:2 for *n. apacheana* and 9:1 for *n. nokomis* as an average over the sites visited. Females of *n. nokomis* are quite scarce in Colorado.

The range of *S. nokomis nitocris* is restricted to northern Arizona, New Mexico and south-central Colorado along the New Mexico border. We feel that *S. nokomis nigrocaerulea* (Cockerell and Cockerell) should be treated as a synonym of *S. nokomis nitocris* because it evidently represents an eastern outpost of the latter subspecies. Occasional New Mexico specimens are larger than material from the White Mountains of Arizona, and sometimes more darkly marked, but we do not feel this varia-

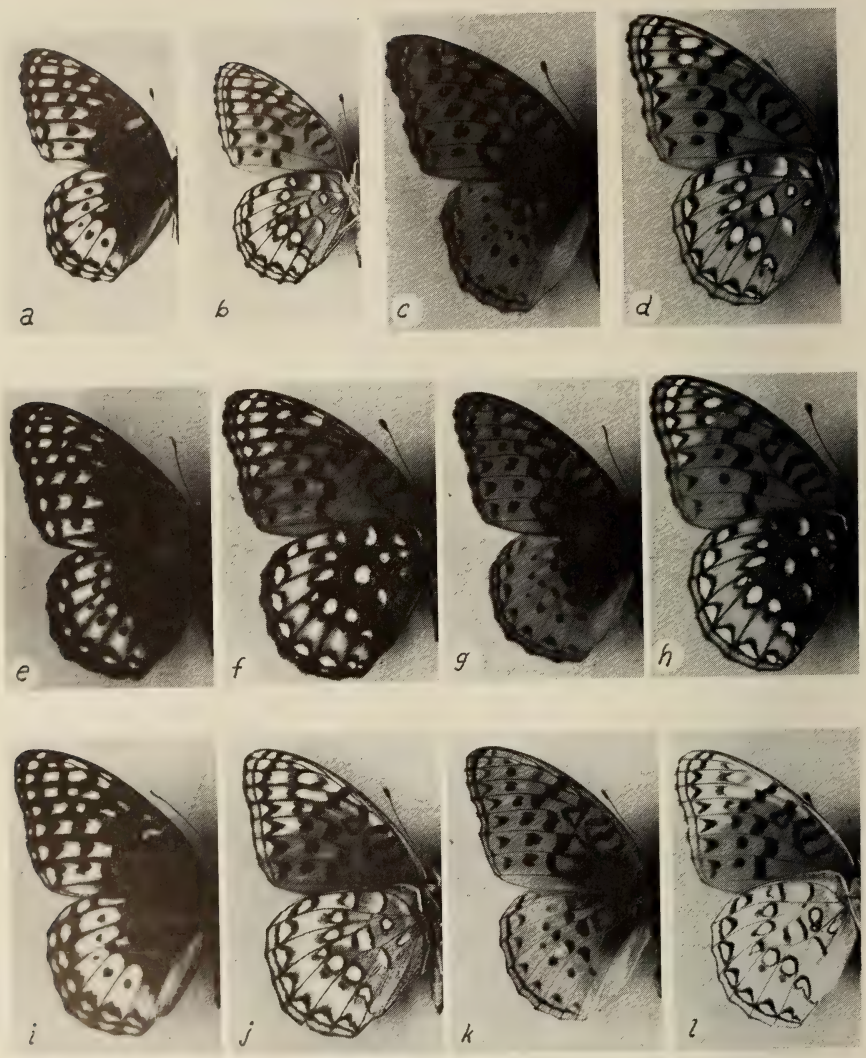


Fig. 2. a-d. *S. nokomis nokomis*, Unaweep Canyon, Mesa Co., Colo., 6000′. b, c, Female, 20-viii-1967; c, d, male, 18-viii-1967.

e-h. *S. nokomis nitocris*. e, Female, Willow Creek, Catron Co., New Mex., 25-viii-67, 8100′; f, female, Pine Creek, Gila Co., Ariz., 7-viii-67, 5400′; g, male, Alpine, Apache Co., Ariz., 17-viii-67, 8300′; h, male, Pine Creek, Gila Co., Ariz., 7-viii-67, 5400′.

i-l. *S. nokomis apacheana*, Round Valley, Inyo Co., Calif., 5000′. i, j, Female, 24–viii-1968; k, l, male, 11-viii-1963.

tion sufficient to warrant nomenclatural distinction. The New Mexico insect was originally described from Beulah. This has created some confusion as Beulah does not currently exist as a town. It is a mail route in the Sapello Valley, San Miguel Co., New Mexico. Farming and ranching have essentially wiped out the habitat for *nokomis*. We would include here the specimen taken by Rotger in Conejos Co., Colorado and described in Brown (1957b).

In some species of *Speyeria*, there is considerable change in discal color intensity as a function of altitude. *S. mormonia* is a good example. We considered this to be the situation with *S. nokomis*. Examination of collection sites indicates that both *n. nokomis* and *n. nitocris* are found at comparable altitudes although the latter extends into higher altitudes. The ecologies of the respective habitats are quite different. It is on basis of fascia, habitat, and geographical location that we have separated the two subspecies. It should be noted that the underside color of *n. nitocris* fades quite rapidly on the wing, and this may have been the reason for confusing the two subspecies in the past. The very dark color of the disc in fresh *n. nitocris* is most distinct from the color of the same area in fresh *n. nokomis*.

We would thus propose a revised treatment of *S. nokomis* as follows:

SPEYERIA (SPEYERIA) Scudder, 1872

Type: *Papilio Nymphalis Phaleratus idalia* Drury, "1770" [1773]
Argynnis Auctorum
‡*Dryas* Hübner, [1806] (Opinion 278, name 75) (*partim*)
Neoacidalia Reuss, 1926 (*partim*)

612 nokomis (Edwards), "1861–3" (1862)
a n. nokomis (Edwards), "1861–3" (1862)
form *valesinoidesalba* (Reuss), 1926 (*emendatio*)
b n. nitocris (Edwards), "1874–6" (1874)
nigrocærulea (Cockerell and Cockerell), 1900
ab. *rufescens* (Cockerell), 1909
nitrocris dos Passos, 1964 (*lapsus calami*)
c n. cœrulescens (Holland), 1900
cærulescens McDunnough, 1938 (*lapsus calami*)
d n. apacheana (Skinner), 1918
nokomis (Edwards) 1873 (*nec* Edwards, "1861–3" [1862])
e n. wenona dos Passos and Grey, 1945

Acknowledgments

The authors would like to thank the following collectors who supplied specimens for examination, and information on habitats and ecology: J. D. Eff, Bruce Harris, J. H. Masters, and R. E. Stanford. Scott Ellis provided extensive habitat notes for Colorado. Special thanks are due F. Martin Brown of Colorado Springs, Colorado and L. Paul Grey of Lin-

coln, Maine who provided collection data, reviewed the manuscript, and made many pertinent comments during the preparation of this paper. Mr. W. H. Shaughnessy of the Academy of Natural Sciences, Philadelphia kindly provided data for specimens collected by Skinner in New Mexico.

Mr. Kilian Roever of Phoenix, Arizona kindly provided additional Arizona collection records and made some additional comments upon the habits of *n. nitocris*. He noted that females of this species generally oviposit in shaded or semi-shaded open woods where there are seeps, although one female was observed ovipositing in an open meadow formed by an old beaver dam. Also supplied were records of specimens referable to *n. apacheana* from Garfield, Iron, Kane, and Washington Cos., Utah. The intermediate situation between *n. nokomis* and *n. apacheana* was noted as discussed above.

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OBSERVATIONS ON THE BIOLOGY OF *OCNEROGYIA AMANDA* STGR. (LYMANTRIIDAE), A PEST OF *FICUS* IN IRAQ

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The comparison of the present observations with data in the literature has shown that there is a considerable lack of information about the moth pest, *Ocnerogyia amanda* Staudinger on figs in Iraq. It is intended, in this paper, to cover at least some of these existing gaps.

This work was carried out in Baghdad from April to July, 1968, both in the field and in the laboratory.

The eggs are laid in groups of about 20 or more. Similar data was obtained by Buxton (1920) and Ramachandra (1922). Most eggs can be found on the lower side of the leaves and to a lesser degree on the upperside of leaves, on the trunk or on dry leaves under the trees.

The newly-hatched first-instar larvae disperse over the leaf on which the eggs were laid and begin feeding. Movement of larvae is limited while small but becomes more extensive as they grow older. The feeding behaviour of the larvae varies with their size. First-instar larvae skeletonize the leaf surface; second-instar larvae make small holes in the leaves; older larvae eat great holes in the leaves or devour them completely except for the main ribs. The early-instar larvae are not noticeable on the tree, but those of later instars are conspicuous because of their greater size and long yellowish body hairs.

The larvae exhibit a definite diurnal migration. They feed at night but take shelter among dead leaves or soil beneath the fig trees during the day (Buxton, 1920; Ramachandra, 1922). According to Scott (1929), fig trees neighbouring mud walls were severely attacked because larvae thrive where they can find shade at certain times of the day; moreover larvae feed on the lower leaves during some part of the day whereas they feed on the more exposed foliage at night. It was found during this study that the larvae do not feed during the hot periods of the day. During this period, they congregate in places which are cooler and more sheltered than are the leaves. Such places are parts of the trunk, especially near the base, and sheltered parts of garden walls. Both young and older instar larvae may be found in such aggregations. The larvae

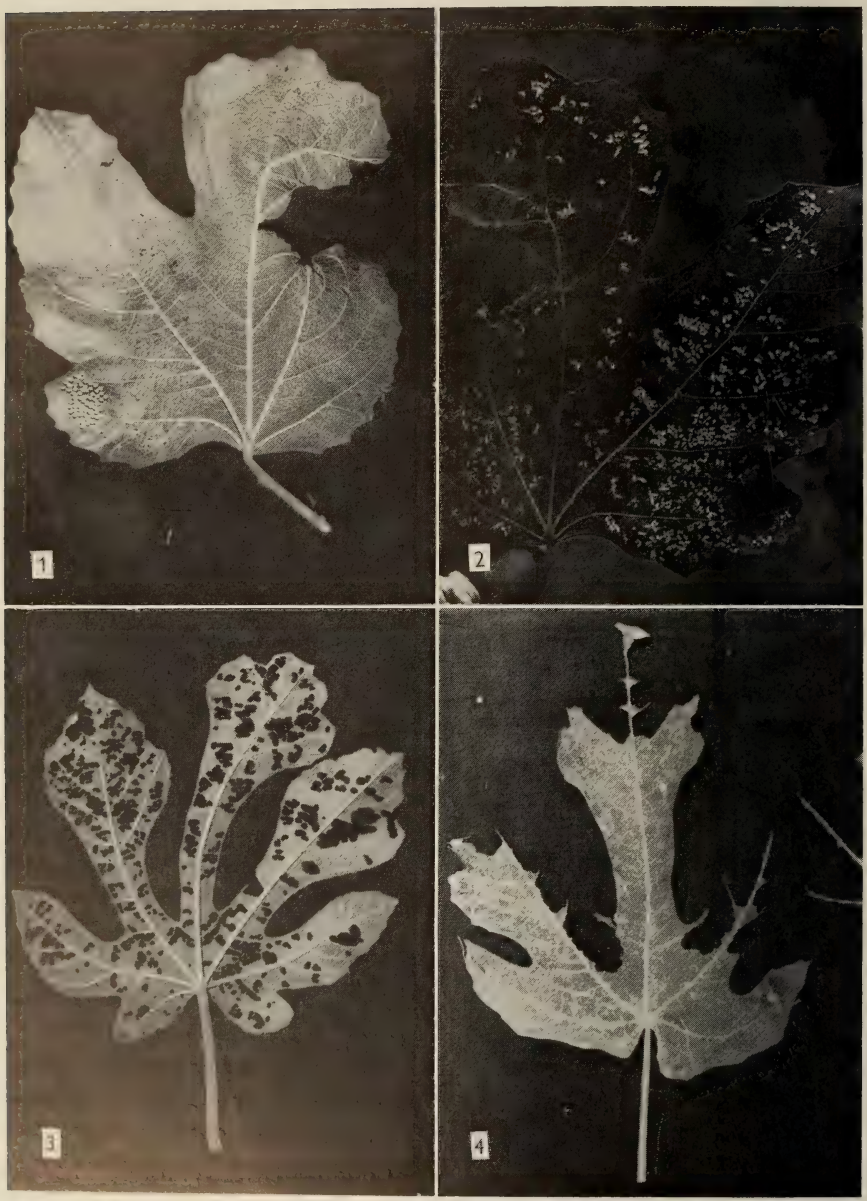


Fig. 1. Eggs of *Ocnerogyia amanda* Stgr.

Figs. 2–4. Damage to fig leaves by larvae. 2, By first-instar larvae; 3, by second-instar larvae; 4, by late-instar larvae.



Figs. 5, 6. *Ocnerogyia amanda* Stgr. 5, Late- instar larva; 6, cocoon.



Fig. 7. Congregation of larvae at the base of a trunk.

were observed to feed in the late afternoon during July. It is possible, however, that during the hottest periods of the year feeding is restricted to the hours of darkness, especially on more exposed and unprotected fig trees.

According to Ramachandra (1922), the larvae have six moults. Larval and pupal stages last about 24 days and 8–11 days respectively. Scott (1929) reported somewhat similar results, the egg, larval and pupal stages being 5–6, 21 days and about a week respectively.

The cocoon is spun of rough yellowish-grey silk. The texture is irregular and the pupa is fully visible in its cocoon. Laboratory observations have shown that the larvae do not spin the cocoons on plain surfaces, but only on the sides or on the top of the cage. In nature, they do not occur on green leaves, but can be found on shaded trunks, usually the lower parts, and in dry leaves. Other preferred sites are sheltered parts of garden walls. Usually, congregations of pupae occur in suitable places. The congregation of the pupae is similar to that of the larvae; the old larvae select obviously microclimatically favourable sites for pupation, whereas the younger larvae occur in such places only temporarily and migrate to their feeding sites. The number of pupae observed in one congregation is usually three to five. The distance from a tree is usually not more than about five meters.

The adults can be caught easily in light traps in late evening hours. There is sexual dimorphism, the female being light brown while the male is somewhat smaller in size and with orange hind wings.

The seasonal occurrence of the moth was noted to be continuous throughout the summer. This is considered as unusual among Mesopotamian Lepidoptera, which generally aestivate during summer (Buxton, 1920). It was found during the present investigation that adults occur in the last 10 days of May. The eggs and young larvae were observed during the first half of June and the pupae and adults at the end of June and in the first half of July. Obviously, there are at least two generations and perhaps three a year. Ramachandra (1922) similarly reported the duration of the entire life cycle as being about one and one half months and that there are probably three generations a year.

The lack of aestivation in this moth during the unfavourable hot summer months is obviously permitted by the ability of the larvae to migrate to protected shelters and return to feeding sites at times when conditions are cooler.

O. amanda is very important economically causing serious damage to fig trees. Larvae feed on the leaves and sometimes devour them com-

pletely. Often the greater parts of trees were observed to be practically leafless with only the ribs left and none of the leaf tissues. The shrivelling and dropping of fruits may be also observed, and is caused by a sequence of leaf damage and water-regime to the damaged tree. Other factors may also be responsible for it, such as the exposure of fruits to direct hot sunlight and, in some cases, infestation by a fly, which stunts the growth of fruits and causes their shedding.

According to Buxton (1920), this pest should be fairly easy to keep in check; the Arab growers burn the dead leaves and other rubbish in heaps beneath the trees. This destroys all stages of the insect as well as its hiding places. But this study has shown that such a control method is not sufficient because burning does not destroy all individuals of the pest; the trunks of the trees and garden walls are not touched. More recent methods should provide adequate control of this insect pest. If the population of larvae reaches economic levels, treatment by insecticides must be undertaken during that period of the day when the larvae are present and feeding on the trees—i.e. late afternoon, evening and night.

Acknowledgments

Sincere thanks are due to Dr. J. Moucha of the National Museum at Prague for identification of the insect species and for further valuable information. The writers wish also to express their gratitude to the Biological Research Centre of the Iraqi Council of Research for providing the space, facilities and the opportunity to carry out this work.

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THE LIFE HISTORY OF *ORNITHOPTERA ALEXANDRAE* ROTHSCHILD

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During the years 1967 and 1968 some data were obtained on the life history and behaviour of *Ornithoptera alexandrae* Rothschild, the largest known species of Rhopalocera; the study was completed in 1970. The geographic distribution of *O. alexandrae* is limited to a relatively small area in southeastern New Guinea. However, within its range there are many areas where the butterfly does not occur although the hostplant grows prolifically. The main habitat is a low and relatively flat region, but it has also been observed at altitudes up to 900 meters.

O. alexandrae is monophagous. Its hostplant is *Aristolochia schlechteri*, a vine having rather large, thick leaves and stringy stems covered with a layer of strongly ribbed cork. The flower is shaped like a starfish with three long arms and is dark purple-brown with a yellow heart. The fruit is green, shaped like a small cucumber, 20 to 30 cm long, strongly ribbed longitudinally and has a rough skin. It matures slowly and when fully rotten the seeds fall to the ground and are carried away by rainwater generally over short distances, resulting in a number of plants growing in a restricted area. In primary forest the vine reaches the top of tall trees of over 40 meters high. When larvae were transferred to *Aristolochia tagala*, a plant more generally distributed, it was accepted readily and the larvae developed normally, although at a much faster rate than larvae feeding on their natural host. Data recorded show a rapid growth as was the case with larvae of *Papilio aegeus* when reared on parsley or carrot leaves (Umbelliferae) instead of their natural foodplants (Rutaceae) (Stride & Straatman, 1962). When three larvae, obtained from eggs collected in the field, were reared on *A. tagala* they went through six instars instead of the usual five. It is not known whether this is hereditary or environmental. The female butterfly does not oviposit on *A. tagala*.

Oviposition. Generally a single egg is laid on the under surface of an old leaf of the hostplant. In secondary forest where this plant is not very tall, the egg is laid from a few centimeters above the ground to about one meter above it. On several occasions a female was observed laying on other objects than the foodplant such as a grass stem growing at a distance of a few centimeters from one of the main stems of the *Aristolochia* vine. In primary forest, however, oviposition may take place at a considerable height above the ground.

Egg. Large, light yellow, flattened at the base. Diameter 3½ mm. Covered with a thick layer of a bright-orange sticky substance, which fixes it firmly to the surface on which it is laid. Incubation period varying from 11 to 13 days.

First-instar Larva. Ground colour dark wine red. All segments with long tubercles of same colour as body; tubercles fleshy for about one-fourth their length, remaining part stiff and black with numerous black spines. Two dorsal tubercles on the fourth abdominal segment light red as is dorsal saddle mark joining them on the same segment. Saddle mark divided mid-dorsally by a narrow black line. Head, prothoracic shield and legs black; prolegs dark, fleshy. Newly hatched larva seven to eight mm long. Osmaterium orange yellow.

Second-instar Larva. Ground colour reddish black. Tubercles proportionately longer, all fleshy and without spines, latero-dorsal ones the longest. Dorsal and latero-dorsal tubercles on thoracic segments two and three, and dorsal ones on abdominal segments one, seven, eight and nine red; two dorsal tubercles on abdominal segment four creamy-white with pink tips; remaining tubercles of ground colour. First thoracic segment with four tubercles, following three segments with eight; abdominal segments two to eight with six; ninth abdominal with four and the last segment with two tubercles.

Third- to final-instar Larvae. Ground colour unchanged. Tubercles without spines, of nearly equal length except for the ventro-lateral ones which are very short. In ultimate instar, body tubercles proportionately smaller than in early instars. All bright red except two dorsal ones on fourth abdominal segment which remain creamy white with pink tips. Conspicuous saddle mark extending and narrowing down to spiracles. Some larvae with an additional creamy spot on third abdominal segment. Measurements of a large, mature larva: length 118 mm, greatest width 30 mm; headcapsule length, 12 mm, width 11 mm; longest tubercle, 13 mm. Some larvae have six instars instead of the usual five, and these producing the largest butterflies.

Adult. The size of the butterfly varies considerably. The average length of the forewing in the male is 97 to 100 mm, in the female 118 to 126 mm. Many specimens are smaller, few are larger. One previously unrecorded feature is that some males have translucent, yellow discal spots on the hind wings, homologous to those of *priamus* and *victoriae*.

Duration of stages. The following data were recorded for the average duration of each stage:

on *Aristolochia schlechteri*		on *Aristolochia tagala*	
egg	12 days	egg	12 days
first instar	5 days	first instar	3 days
second instar	7 days	second instar	6 days
third instar	9 days	third instar	8 days
fourth instar	11 days	fourth instar	9 days
fifth instar	20 days	fifth instar	10 days
sixth instar	22 days	sixth instar	14 days
prepupa	3 days	prepupa	3 days
pupa	42 days	pupa	42 days
Total	131 days	Total	107 days

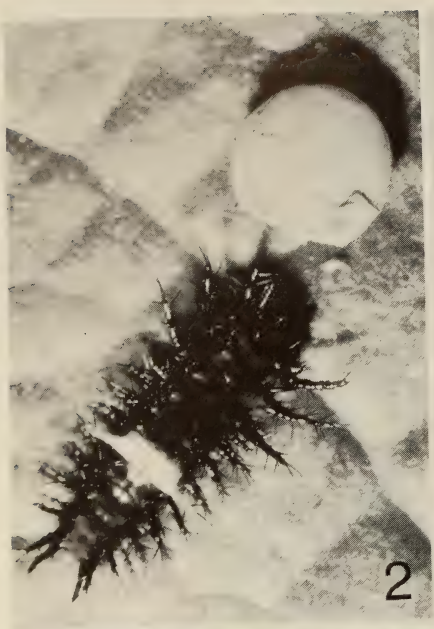
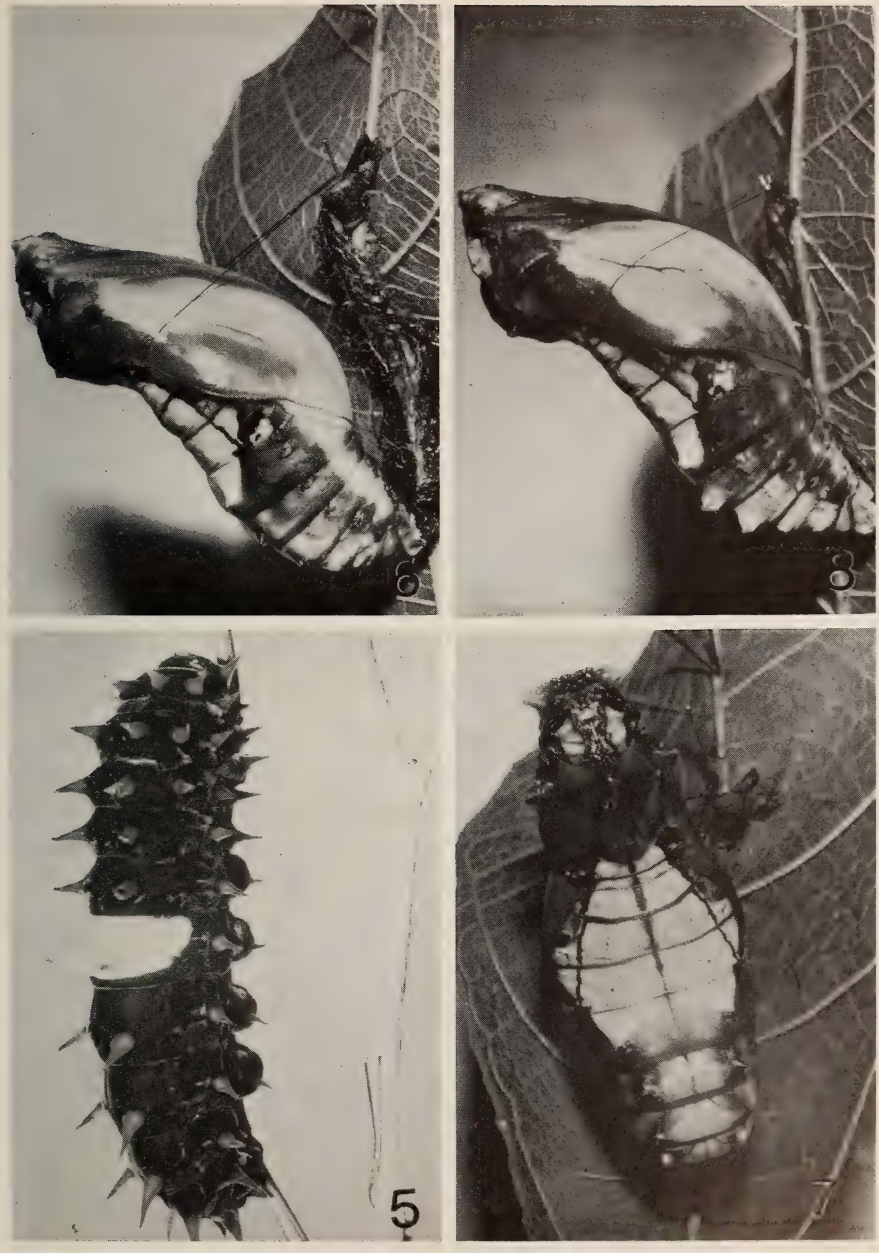








Fig. 1. *Ornithoptera alexandrae* Roths., first-instar larva.
Fig. 2. *O. goliath* Oberth., first-instar larva.
Figs. 3, 4. *O. alexandrae*. 3, Second-instar larva; 4, third-instar larva.



Figs. 5–7. *Ornithoptera alexandrae* Roths. 5, Sixth-instar larva; 6, pupa, lateral; 7, pupa, dorsal.

Fig. 8. *O. victoriae epiphanes* Schmid, pupa, lateral.

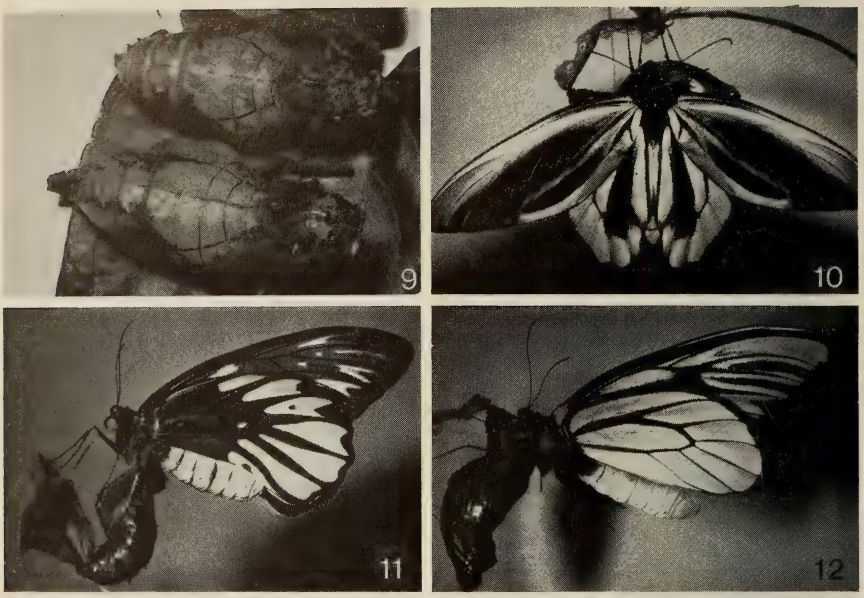


Fig. 9. Pupae of *Ornithoptera alexandrae* Roths. (below) and *O. priamus poseidon* Dbdy. (above).
Figs. 10–12. *O. alexandrae*, adults. 10, 12, Male; 11, female.

In the higher altitudes of its range the total figure may reach 180 days depending on the locality.

It was observed that larvae feeding on *Aristolochia schlechteri* spend much time in search of suitable leaves and stems. However, those feeding on the succulent and soft parts of *Aristolochia tagala* rarely move around and appear to have a longer average daily feeding time.

Feeding habits. Shortly after hatching the larva devours its eggshell, which provides sufficient food for the next 24 hours. It then commences feeding on tender shoots and young leaves. Later instars feed on older leaves and stems. Fifth and sixth instar larvae feed mainly on the stringy stems and shortly before pupation one or more stems of the host vine are severed, causing the upper parts to wither. If the plant is young, the lower part is eaten down to the ground.

Pupation. The larva may wander for 24 hours or longer to locate a suitable site for pupation, which sometimes occurs at a considerable distance from where it was feeding last. The longest recorded distance was nearly 10 meters. It generally pupates under a leaf of any kind of shrub or tree other than the hostplant, rarely on stems, at an average height of

one to two meters above the ground in secondary forest, but considerably higher in primary forest.

Pupa. Ground colour light brown. Wing cases yellow, a broad light-brown streak along lower margin. Abdominal segments brown ventrally and yellow dorsally, with a yellow latero-ventral streak. Dorsal saddle mark bright yellow, extending over segments one to five. Middorsally divided by a narrow dark brown line; a similar line running laterally below wing cases. Thorax dark brown, tegulae bright yellow. Abdominal segments five to eight with two very short, sharp, black processes each. Pupa very closely resembling that of *O. victoriae.* Duration of pupal stage from forty to forty five days.

General observations. Female butterflies appear to follow a determined flight pattern when ovipositing. This is suggested by the fact that larvae in different stages of development, together with one or more pupae or exuviae, may always be located on or near the same foodplant, while other plants growing in the vicinity remain free of specimens the year round. It is possible that females, in their search for suitable conditions for oviposition, are stimulated by plants which already do support or have previously supported early stages. Single larvae are only found on small plants.

Although it has not been possible to determine the longevity of the adults it is believed to be similar to that of *O. priamus.* Some males of *alexandrae* were clearly marked after they emerged from the pupa, and then released in a garden. A few of these specimens established themselves for the duration of their adult life in the same garden, where both hostplants and flowers were prolific. After 11 weeks, one male was found caught in a large spiderweb. Another died in the same way after nearly 12 weeks.

Predators and diseases. Several larvae have been found marked with numerous rustbrown dots, sitting motionless without feeding. They died after several weeks and may have been killed by a fungus disease.

On one occasion a larva covered with eggs of a Tachinid was collected, but continued feeding, pupated normally and produced the adult. Apparently the parasite eggs did not hatch or the resulting maggots did not survive. A native collector once had a pupa which produced a large number of small, black wasps, probably Chalcididae. Otherwise larvae of *O. alexandrae* are rarely attacked by parasites. Prepupae and soft, fresh pupae are sometimes killed by ants and wasps and mature larvae and pupae are attacked by tree rats and small marsupials. When not mating both sexes may be seen, generally flying high (average 20 to 30 meters above the ground) and in a single direction. In the forest, males are seldom seen as they remain in the shade of the high canopy and avoid open or exposed areas.

Fecundity. Two females were taken on the wing while ovipositing. Both specimens appeared in good condition, but it was impossible to make an accurate estimate of their age. They were kept alive and fed daily with a sucrose and honey solution. After 12 days in captivity both specimens were killed. One female had laid one egg; dissection of its abdomen produced another 16 mature eggs. On the basis that not more than 10 eggs had been laid before its capture, we can estimate a total capacity of 25 to 27 eggs. Dissection of the second female produced a total of 12 eggs of which two were immature.

Acknowledgments

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A HOST PLANT FOR NORTHERN POPULATIONS OF *EUCHLOE OLYMPIA* (PIERIDAE)

Following my report in the Annual Summary for 1967 of *Euchloe olympia* (Edwards) being sighted in large numbers between Deep River and Stonecliff, some 75 miles farther north and possibly east of the Killaloe, Ontario records reported in the 1966 Annual Summary, I unsuccessfully attempted during the succeeding years to discover the host plant of this northern population.

It was not until May 23 of this year, that I was fortunate enough to observe two females of *Euchloe olympia*, at 1430 hours and a temperature of 76° F., ovipositing on *Arabis glabra* (L.) Bernh. This plant is regionally (although probably incorrectly) called Tower Mustard. Doubtless other Cruciferae are fed upon by *olympia* in this area but these are yet to be determined.

Identification of the host plant was very graciously made by Mrs. Mary Moore of the Petawawa Forestry Station, Canada Department of Fisheries and Forestry.

S. A. LINDSAY, *Deep River, Ontario.*

PAPERING LEPIDOPTERA IN GLASSINE ENVELOPES

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In several previous volumes of the *Journal*, especially in the late fifties and early sixties, there appeared articles on papering Lepidoptera. Many of these recommended using paper triangles instead of glassines because of certain defects in usage of glassines. It is my purpose in this short note to describe my usage of glassine envelopes and to give a few tips on how to avoid some of the difficulties mentioned by others.

I use glassine envelopes exclusively in papering all Lepidoptera captured by me, for the following reasons: ease of use and visibility.

Ease of use. I find it difficult, when trying to use triangles, to get the flaps to stay down. I also dislike to have to prepare triangles. I have also found that in certain small, fat bodied skippers and in many sphingid and arctiid moths the trouble getting them to stay in place while folding the flaps over can cause the specimens to become rubbed or to slide out of place. With glassines there are no such problems. The glassines I use have only one flap (along the top edge), and with my usual size glassines (see below), I have only to fold the flap over and make a good stiff crease. The flap stays folded. Also, the pressure that is applied to the specimen by the front and back of the envelope, sealed as it is on three sides, holds the specimen in place without slippage.

Visibility. This is the most important quality the glassine envelope has over the triangle for most collectors. It allows you to see exactly how the specimen is placed in the envelope and also allows you to determine the condition of the specimen without having to handle it more than necessary.

How to select the proper glassine to use. First, use only glassines *without* gummed flaps. Many collectors prefer to use glassines *with* gummed flaps because they can be licked shut. Unfortunately, they can also be "licked shut" by humidity in the atmosphere. I have found that if after papering a specimen in a glassine that has no gum on the flap, I fold the flap over, lay it on a piece of pasteboard or other firm, flat surface, and run a curved, smooth surface over the crease of the flap that the resulting stiff crease will not unfold. Secondly, use the smallest size of glassine that the specimen will fit into without touching either of the two sides and without coming into contact with the crease of the flap (remember that you will be applying pressure to the flap crease). For

most lycaenids, pierids, geometrids, and hesperids, as well as other Lepidoptera of this approximate size I prefer the standard two inch by two inch glassine coin envelope. These come with the flap uncreased and should cost four to five dollars per thousand at the most. For larger specimens such as *Danaus plexippus* (Linnaeus) or *Limenitis archippus* (Cramer), or for *Papilio* I use the various standard size postage stamp envelopes. The sizes to use will depend on the size of the specimen. The amount to buy will depend on which butterflies and moths you are collecting, or which are commonest in your area and are collected most. I suggest that you purchase a selection of sizes ranging from number ones (one and three-quarters by two and seven-eighths inches), to number fours (three and one-quarter by four and seven-eighths inches). If you need larger sizes they are available. Try out the different sizes and see which you use most. Once you know which size or sizes you use the most, buy these by the thousand. They are much cheaper this way.

How to use your glassines. This will vary with individual preference. I use my glassines as follows. When I go out collecting, I carry in an upper shirt pocket about one hundred number four glassines. In front and in back of this pile of glassines are pasteboard separators from the boxes of one thousand that I have bought. The separator closest to me prevents perspiration from coming in contact with the glassines. This is important since glassines will wrinkle when wet. The front separator, the one furthest away from me, is used to divide the empty glassines from those containing specimens. Having caught a specimen in my net, I "pinch" it and then remove it from the net with my forceps. Holding the forceps in one hand, I reach into my pocket and between the two separators with the other and remove an empty glassine, opening it one-handed as I remove it; this takes practice, but not much. I then insert the specimen into the envelope with the forceps, put away the forceps, spread the separator and the pocket front apart with two fingers of one hand and *carefully* insert the glassine containing the specimen with the other hand. Once you have practiced this technique a few times it will become almost automatic. Take care, however, never to "cram full" the pocket. If it becomes a tight fit and a glassine does not go in smoothly simply transfer some of the full glassines elsewhere.

Having collected enough specimens to make a good day, I return home and, removing the glassines, place them in piles according to species. I then prepare the permanent storage glassines.

Preparing permanent storage glassines. Having removed the specimens I wish to discard or spread, I then separate each pile, one pile at

a time, by sex. I now take my two by twos and put the appropriate data on the back flap of each envelope. I use a nylon tipped pen with a quick, surface-drying ink. You may, if you wish, use a typewriter or rubber stamp, but since glassines are not porous you will have to wait some time for the ink to dry. With a surface-drying ink such as is used in felt-tipped marking pens you eliminate the waiting. By the time you finish the last envelope in the species from one pile, the first will be well dried.

Putting the specimen in the glassine. Using my forceps I remove the specimen from the number four envelope and place it in the prepared two by two with the antennae in the usual "down between the wings" position. Carefully removing the forceps I adjust the flap to the proper height and put a light crease on the edge with the forceps. I then, as described above, put a permanent stiff crease on the edge. The specimen is then entered into the record book and placed in permanent or temporary storage.

Storing specimens. Many people use cigar boxes or other containers for storing papered Lepidoptera. With my system of two by twos however, I can use plastic coin storage boxes with tight fitting lids. These boxes, approximately two and one-quarter by two and one-quarter by nine inches are made specifically to hold two by two inch coin envelopes. It is possible to arrange the specimens in any order I wish, add an insecticide, put the top on and tape the box shut, and put the sealed box away in storage for years without the necessity of further care. Labels are available to go on the ends of the storage boxes, thus the contents are recorded and the proper box can be retrieved with little effort.

Warnings. Never use an insecticide in a plastic box that will react chemically with the plastic. Paradichlorobenzene and other oil based insect killers are *verboten*! I use a powdered insecticide and fungicide combination such as is used in many museums. This works just fine. Another precaution is to allow all specimens two to three weeks to dry out thoroughly before sealing the box and to make sure that as much moisture as possible is excluded from the box. I suggest sealing boxes on the second of two dry days or in winter when the moisture content of the air is low. In the tropic and humid regions I recommend the use of warm air to dry out the box before filling. Use your own judgment on how to go about it, but *never* heat the box in a drying oven. At best it will probably warp and at worst it will melt.

Relaxing specimens in glassine envelopes. As stated above, glassine envelopes are non-porous. They cannot, therefore, be just placed in a relaxing box like triangles can. A simple method of relaxing such glas-

sined specimens is as follows. Take the envelope, and with a pair of good straight scissors cut off the smallest bit you can manage all along both sides and also along the top. Cut as close to the specimen as possible, leaving extra glassine above the specimen. Taking the extra glassine in the forceps, thus keeping the specimen immovable between the remaining part of the glassines back and front, place the specimen and remains of the envelope in the relaxing box. The glassine will curl from the humidity and expose the specimen on three sides to the atmosphere in the box. The specimen will not be "soaked" if the glassine is placed directly on the wet sand or sponge you use to hold the moisture since water will not penetrate the non-porous glassine.

If you have used a waterproof ink, and have put the data on the front of the envelope you can make sure that the data is included on the glassine that goes into the box with the specimen. If the data is on the flap (which you cut off along the top to open the envelope), you may put the flap in with the specimen or put it under the relaxing box, as I do. Choose the method that best suits you.

When the specimen has relaxed, remove it using the extra glassine again, and go to work.

The above are the techniques I use to get excellent results with glassine envelopes, at the lowest expenditure of time, effort, and cash. Please remember that circumstances vary and that modifications or substitutes should be used to suit the individual collector.

HYBRIDS AMONG SPECIES OF *HYALOPHORA*

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Although hybrids between species of *Hyalophora* are well known and the triple hybrid (*H. gloveri* ♂ × *H. rubra* ♀) ♂ × *H. cecropia* ♀ has been described (Collins and Weast, 1961), there does not appear to be any description of the triple hybrid (*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀ or of a hybrid which combines all four species. The object of this investigation was to raise the quadruple hybrid [(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀ and to study the effects of foodplants on the rate of growth and the size of cocoons and adults.

TABLE 1. *Hyalophora* hybrids. Comparative growth of larvae on different food plants[a]

Foodplant	Number	No. Surviving		% Survival		Larval Stage Mean Days
		To Pupa	To Adult	To Pupa	To Adult	
H. cecropia ♂ × *H. gloveri* ♀						
Willow	17	15	14	88	82	42
Cherry	25	18	16	72	64	54
Maple	25	20	18	80	72	75
Alder	21	5	3	24	14	70
[(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀						
Willow (A)	27	23	13[b]	85	48[b]	47
Willow (B)	27	12	10[b]	44	37[b]	52
Cherry	55	39	29[b]	71	53[b]	44
Tamarack	20	2	1	10	5	48

[a] Data on the trihybrid were incomplete and cannot be reported. However, survival was excellent, and the larval stage was about 35 days on both willow and cherry.
[b] Results are for those that had emerged within 12 months of pupation. Most of the others were still alive and emerged the second summer.

Procedure

A male and a female were put in an eight cubic foot wire cage to secure a mating. Copulation began in the early morning and continued until the evening. The female was put in a paper bag and left about three days to lay her ova. The ova were placed in a typewriter ribbon box and hatched in about 10–15 days.

The larvae were fed washed leaves of the foodplant, the stems of which were put through holes in the tops of plastic boxes containing water. Most of the larvae were grown in fish tanks which were covered with mosquito netting and kept indoors at a temperature which varied from 20–30° C. The tanks were cleaned and the larvae were fed at frequent intervals. In some cases larvae were grown outdoors in mosquito netting sleeves or transferred to large wire cages in the fourth and fifth instars to prevent crowding. The larvae either spun in their containers or were put in paper bags to spin. Pupae were overwintered in a cool place. Measurements were made of the size of the cocoons and the wingspans of the adults. Characteristics of the larvae were recorded at each stage.

Discussion and Results

(see Tables 1 and 2)

H. cecropia ♂ × *H. gloveri* ♀

After the first instar, larvae were raised outdoors in sleeves. The larvae grew fastest, had the lowest mortality, spun the largest cocoons, and

TABLE 2. *Hyalophora* hybrids. Size of cocoons and adults

Foodplant	Size of Cocoons (mm)		Mean Wing Length (mm)[a]	
	Mean Length	Mean Circumference	Males	Females
H. cecropia ♂ × *H. gloveri* ♀				
Willow	54	88	62(7)	65(5)
Cherry	49	80	53(9)	59(7)
Maple	45	73	52(12)	55(5)
Alder	41	67	44(1)	55(2)
(*H. cecropia* ♂ × *H. gloveri* ♀) × *H. rubra* ♀				
Willow	65	100	60(16)	64(15)
Cherry	60	96	56(9)	60(9)
[(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀[b]				
Willow (A)	58	80	55(4)	59(9)[c]
Willow (B)	49	70	50(7)	52(3)
Cherry	57	76	57(15)	60(14)
Tamarack	44	71	—	53(1)

[a] Measured from the base to the apex of the right forewing. The number within parentheses indicates the number of specimens measured.
[b] Wingspan of the female *H. columbia* was 50 mm, while that of the hybrid male was 59 mm.
[c] Results are for those which had emerged within 12 months of pupation.

formed the largest adults when raised on black willow (*Salix nigra*). Black cherry (*Prunus serotina*) was the second most suitable foodplant, sugar maple (*Acer saccharum*) was third and alder (*Alnus*) was poorest.

(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀

Of 253 ova, 222 hatched from May 5 to 8, 1967. They were divided into two groups. One was fed weeping willow (*Salix babylonica*) and the other was fed black cherry. Because of the large number of larvae, only a representative sample was carried to the adult stage. The larvae on both foodplants spun in about 35 days. Both cocoons and adults were slightly larger when the larvae were reared on willow, suggesting that this is a slightly superior foodplant to cherry.

The adults (Figure 1) varied in color but had stronger *H. rubra* Boisduval characteristics. The cocoons also strongly resembled those of the *H. rubra*.

[(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀

A mating was obtained on May 13, 1968. The pair broke up at about 8:30 PM. A total of 129 ova were laid, all of which hatched from May 27 to 29. Twenty were put on tamarack (*Larix americana*), 54 on weeping willow, and 55 on black cherry. The tamarack was obtained from a peat

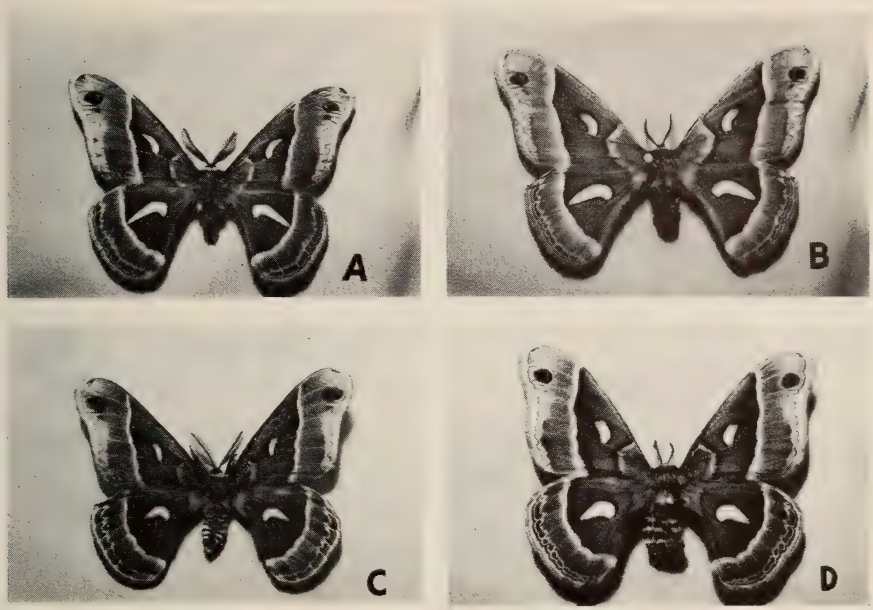


Fig. 1. *Hyalophora* hybrids. A, B, (*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀, male and female; C, D, [(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀, male and female.

bog in Sussex County, New Jersey. Two types of weeping willow were used: one (A) was more limber and longer lasting, whereas the other (B) was brittle and required more frequent replacement. These foodplants were chosen because the hybrid and triple hybrid both did well on weeping willow and black cherry. *H. columbia* Smith has been raised on choke cherry and in nature feeds only on tamarack.

The adults (Figure 1) resembled giant *H. columbia*, but were more reddish and somewhat lighter in color. Cocoon size and survival rate were greatest for specimens grown on willow and cherry. The larvae did not do well on tamarack and all but two died in the early instars.

Descriptions of the Larvae

(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀

First instar: Bristly black. Appeared to be identical to other members of genus *Hyalophora*.

Second instar: Ground color yellow. Double row of black spots between dorsal tubercles (DT) on segments 2–10, upper lateral tubercles (ULT) and DT on segments 2–10, and lateral tubercles (LT) and ULT on segments 2–11. All tubercles black with yellow base. Frons usually black but sometimes brown. Clypeus silvery greenish, head otherwise black.

Third instar: Ground color yellowish green but turquoise dorsally. Between DT on segments 3–10, one black spot per segment, sometimes two on segment 10. Black spots between ULT and LT on segments 3–11, ventral to spiracles. Sometimes a black spot between ULT and DT on segment 2. Sometimes two per segment dorsal to each proleg and segment 10. Often no spots at all except one on each segment in line with lower lateral tubercles (LLT). Spiracles white or yellow, ringed with black. Lobes yellow green with two black spots. Frons yellow green, clypeus and labrum silver, palpi yellow green with one black setae, mandibles black. DT on segments 2–10 and LT yellow. Other tubercles blue or black with blue base.

Fourth instar: Light to dark green, light turquoise dorsally. Segment 1 dorsally, frons, labrum and palpi yellow green. Lobes yellow-green with black dots. Clypeus blue, mandibles black. Spiracles white ringed with black. DT on segment 1 blue, sometimes reduced to just a dot. DT on segments 2–4 yellow to orange with broken ring of black dots. Other DT and LT yellow. Other tubercles all blue at base to blue-white at tops.

Fifth instar: Green, lighter dorsally. Segment 2 dorsally, lobes and frons yellow green. Frons somewhat yellower than lobes. Clypeus blue grey, labrum grey, palpi turquoise, mandibles black. DT on segments 2–4 all had black ring (broken on segment 4). DT yellow at base, orange or yellow above ring, and bulbous. Tubercles on segment 1 rudimentary black bumps. DT on segments 5–10 and CT yellow. CT slightly bulbous with broken black ring. Other tubercles blue at base to white on top, with black ring around base.

[(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀

First instar: Same as other *Hyalophora*.

Second instar: Ground color yellow to greenish. Row of black spots dorsally one or two per segment. Row of single spots between DT and ULT, and between ULT and LT. Spiracles white with black ring. Head completely black.

Third instar: Mainly olive-green, but turquoise dorsally, except for yellow first segment. One black spot on segments 3–9 dorsally. One spot per segment between ULT and LT on segments 2–11 inclusive, two per segment between ULT and DT, one spot per segment below LT on segments 4–12. All had lower two rows of spots, but not all had upper two rows. Lobes green with three black spots, sometimes fused together. Frons green, clypeus grey, labrum blue-grey, palpi yellow-green, mandibles black. Spiracles yellow ringed with black, tubercles black. DT on segments 3–10 with yellow base. CT yellow anteriorly.

Fourth instar: Basically green, lighter green to blue dorsally. Lobes, frons, and palpi yellow-green. Clypeus blue to grey, labrum grey to black, mandibles black. Spiracles white ringed with black. DT ringed with black. DT on segments 2–10 orange to yellow. DT on segment 1 blue. CT yellow with ring of black dots. Other tubercles blue.

Fifth instar: Green, lighter dorsally. Green lobes, yellow frons, blue to grey clypeus, grey labrum, blue palpi. Spiracles white ringed with black. DT on segments 2–4 orange with black ring. DT and ULT on segment 1 blue to black rudimentary dots. Other tubercles white with a black ring, slightly bluish above ring.

Summary

The quadruple hybrid [(*H. cecropia* ♂ × *H. gloveri* ♀) ♂ × *H. rubra* ♀] ♂ × *H. columbia* ♀ was reared successfully. Willow and wild cherry were excellent foodplants and survival was excellent at all stages. Representative specimens have been donated to the American Museum of Natural History.

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SOME NOTES ON THE PAPILIONIDAE OF MANUS ISLAND, NEW GUINEA

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Manus Island is a relatively obscure island which anchors the westernmost chain of the Bismark Archipelago. It is approximately 150 miles in length and the principal island of the Admiralty Island group. The nearest New Guinea mainland lies some 300 miles south, and Papuan influence is reflected in the fauna of Papilionidae of Manus.

In the past, few specimens have come into the hands of collectors from this remote island, largely due to the hostile natives that once inhabited the land. Also Manus was not situated along major shipping trade lanes, and consequently few opportunities existed for visits by travelers. Webster in 1897 was apparently the first to collect the nearly inaccessible island, but was forced to depart hastily because of the unfriendly natives. He succeeded in gathering some papilionid species, however, and these were included in Seitz's treatment of Indo-Australian butterflies.

The A. S. Meek expedition to the Admiralty Islands and adjacent localities in 1913 was more successful than Captain Webster's. Meek, commissioned by Lord Rothschild of the Tring Museum in England, was able to collect Manus Island during September and October, and to assess

the island's fauna accurately. When Lord Rothschild received Meek's material a report of the species taken appeared in "Novitates Zoologicae," XXII, in 1915. This publication recorded eight papilionid species for Manus of which four were described as new subspecies and another, *Papilio cartereti* Oberthur (= *Papilio weymeri* Niepelt in Strand) was an apparent new discovery deserving species status.

Apart from the collections made by Webster, Meek and a few others, the Admiralty Island group continued to be an essentially by-passed location for many years. Fortunately the author was successful in obtaining the services of a resident collector on Manus in 1968. Papilionidae were supplied at regular intervals for more than a year, and this more recent material substantiates the previous works of Webster and Meek. The annotated list of Papilionidae is herein offered to consolidate and supplement information concerning the Papilionidae of the Admiralty Islands. The arrangement of species follows that of Munroe (1961).

Graphium codrus auratus (Rothschild)

Papilio codrus auratus Rothschild, 1898, p. 218.

Described from 2♀♀, St. Gabriel, Admiralty Island, February, 1897 (Captain H. C. Webster). Rothschild (1915, p. 194) 2♂♂ and 2♀♀ from Manus (Meek Expedition).

The rarest known *Papilio* on Manus. Difficult to net and disdainful of lures. December to March generally favorable flight months. No variation in the few examples received. Distinguished from other *codrus* subspecies by the presence of nine bright yellow spots on each forewing.

Graphium macfarlanei admiralia (Rothschild)

Papilio macfarlanei admiralia Rothschild, 1915, p. 195.

Described from 7♀♀, Manus Island (Meek Expedition).

Especially common to abundant in April and May, but occurring all year round. Sex ratio of adults seemingly equal. This subspecies char-

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Figs. 1–11. Manus Island *Papilionidae* (full expanse in brackets). 1, *Graphium agamemnon admiralis* Rothschild ♂, Oct. 1968, (68 mm); 2, *G. macfarlanei admiralis* Rothschild ♂, Jan. 1969, (74 mm); 3, *G. macfarlanei admiralia* Rothschild ♀, Jan. 1969, (70 mm); 4, *Papilio cartereti* Oberthur ♂, May, 1969, (115 mm); 5, *P. cartereti Oberthur* ♀, May, 1969, (125 mm); 6, *P. ulysses gabrielis* Rothschild ♂, June, 1968, (102 mm); 7, *P. ulysses gabrielis* Rothschild ♀, Oct. 1968, (110 mm); 8, *G. codrus auratus* Rothschild ♀, Dec., 1968, (77 mm); 9, *P. polydorus manus* Talbot ♂, April, 1968, (83 mm); 10, *P. polydorus manus* Talbot ♂ melanic, Dec., 1968, (72 mm); 11, *P. polydorus manus* Rothschild ♀, Dec., 1968 (85 mm).


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Figs. 12–15. Manus Island *Papilionidae*. 12, *Papilio phestus reductus* Rothschild ♂, Oct., 1968, (76 mm); 13, *P. phestus reductus* Rothschild ♀, July, 1968, (68 mm); 14, *Ornithoptera priamus admiralitatis* Rothschild ♂, April, 1969, (140 mm); 15, *O. priamus admiralitatis* Rothschild ♀, April, 1969, (157 mm).

acterized principally by the prominent black margins of both fore- and hind wings. Primaries with greatly reduced green submarginal spots, sometimes barely indicated against the black ground color. Hind wing of the male lacking submarginal band entirely or displaying but a trace of this band in the form of two or three faint spots. Hind wing of the female with a greater area of black ground color, resembling *seminigra* Butler from New Britain.

Graphium agamemnon admiralis (Rothschild)

Papilio agamemnon admiralis Rothschild, 1915, p. 195.

Described from 3♂♂, 5♀♀, Manus Island (Meek Expedition).

Not common in general. Male to female ratio approximately 4 to 3. No appreciable variation. The subspecies characterized in both sexes by the prominent and broad black margins on the upper surfaces. Submar-

ginal spots very greatly reduced, sometimes almost absent. Hind wing resembling that of *P. agamemnon argynnus* (Druce).

Papilio cartereti Oberthur

Papilio cartereti Oberthur, 1914, p. 187 (April 8).
Papilio weymeri Niepelt in Strand, 1914, p. 53; plate 11, fig. 1 (Jan? May?).
Papilio cartereti Oberthur (= *P. weymeri*); Oberthur 1915, p. 499; plate 311, fig. 4602; plate 312, fig. 4603.
Papilio weymeri Niepelt; Rothschild, 1915, p. 194.
Papilio weymeri Niepelt in Strand; Strand 1926, p. 410.
Papilio weymeri Niepelt in Strand; Bryk 1930a, p. 192.
Papilio weymeri Niepelt in Strand (= *P. cartereti* Oberthur); Bryk 1930b, p. 608.
Papilio ? weymeri Niepelt; Munroe 1961, p. 43.

P. cartereti described from 1♂ and 1♀ from the Admiralty Islands collected by the Meek Expedition; named by Oberthur after the navigator Carteret who apparently visited the islands in 1767. *P. weymeri* described from a single female from the Admiralty Islands (not collected by Meek; see Rothschild 1915, p. 192). Rothschild (1915, p. 194) recorded 6♂♂ and 6♀♀ from Manus (Meek Expedition).

It has not so far proved possible to establish beyond doubt the priority of the synonymous names *Papilio cartereti* Oberthur and *Papilio weymeri* Niepelt in Strand, both names without doubt having appeared in the first six months of 1914. Reference to page 528 of *Bull. Soc. ent. Fr.* for 1914 establishes the date for *P. cartereti* as 8th April 1914 (the date of publication for "Seance 25 Mars" in which Oberthur's description appeared). Part 1 of *Lepidoptera Niepeltiana* in which *P. weymeri* was described by Niepelt has the forward dated October, 1913, but the paper cover is clearly dated 1914. Copies in the libraries of the British Museum (Natural History) and the Royal Entomological Society of London give little further information. The copy formerly in the Zoological Museum, Tring (The Museum of Walter Rothschild), however, has been overprinted "Januar" and has a Tring Museum date stamp "Received 25 July 1914." Oberthur (1915, p. 499) states that his own description of the species appeared in March and thus a little earlier ("un peu avant lui") than Niepelt's, which he claims appeared in May ("paru en Mai"). It would seem that there was some delay in the distribution of Niepelt's privately published work; the British Museum (Natural History) did not receive a copy until 22nd May 1920 and the Royal Entomological Society did not obtain a copy until it purchased part of the Joicey Library (the copy in question unfortunately having no original receiving date on it). However, it is known that the description of *P. cartereti* appeared on 8th April 1914 while that of *P. weymeri* appeared certainly sometime before 25th July 1914. Whether one accepts the single overprinting date of January on the ex Tring copy of *Lepidoptera Niepeltiana* or Oberthur's claim

that it appeared in May is at present a matter of opinion. The present location of the holotype of *P. weymeri* is not known to the author; two syntypes of *P. cartereti* are in the British Museum (Natural History).

Only member of the Papilionidae confined soley to Manus Island. Males flying erratically and never seeming to settle. Females less common than males; flying slowly in and among small, stunted brush. June, July and August exceptionally good flight months.

Male greatly resembling *P. bridgei* Math. In *cartereti* ground color very dark brownish-black. Upper surface of the forewing always with a band of eight cream colored spots. Band of hind wing broad and uniformly greyer than spots of forewing. Variation in males almost nonexistent except in size. Female with a generally browner ground color on upper surface than male. Medium band of forewing dusted, smoky light brown. On hind wing a large postmedian band of six brilliant blue patches, terminating at the inner margin with an additional bright orange spot. Submarginal crescents pale orange.

Papilio phestus reductus Rothschild

Papilio phestus reductus Rothschild, 1915, p. 193.

Described from a "type" (holotype) and a further pair (paratypes) from Manus, collected by the Meek Expedition.

Not especially common on Manus. Males slightly more prevalent than females. According to Rothschild in his original description of *reductus*, this form is distinguishable in male by lack of any light spot in cell of hind wing. This characteristic, however, also prevalent in males from New Ireland. Prominent deep-orange patch at the inner margin of Manus Island *phestus* always triangular or nearly so. New Ireland *phestus* with same spot squared or rectangular. In female of *reductus* a greater variation in the number of white and cinnamon spots on hind wing.

Papilio ulysses gabrielis Rothschild

Papilio ulysses gabrielis Rothschild, 1898, p. 217.

Described from a series of ♂♂ and one ♀ from St. Gabriel, Admiralty Islands, collected by Captain H. C. Webster, February, 1897. Rothschild (1915, p. 194 received a further 9♂♂ from Manus (Meek Expedition).

Prevalent the year round and quite common. As many as 15 adults can be netted in an hour, the majority imperfect in condition. Females considerably rarer. Extent of blue in both sexes varying noticeably, but always remaining greatly reduced when contrasted with other *ulysses* subspecies.

Pachlioptera polydorus manus (Talbot)

Papilio polydorus manus Talbot, 1932, p. 155.
Papilio polydorus utuanensis Ribbe; Rothschild 1915, p. 193.

Described from 2♂♂ and 5♀♀ from Manus, Sept.-Oct., 1913 (presumably collected by the Meek expedition). Rothschild (1915, p. 193) recorded 7♂♂ and 6♀♀ from Manus collected by Meek, under the name *P. polydorus utuanensis.*

Common, tending to be abundant periodically. Male-female ratio nearly identical. Some males melanistic, displaying dark suffusion over more normal, creamy white spots of hind wing, thereby approaching *P. polydorus dampieriensis* Hag.

Ornithoptera priamus admiralitatis (Rothschild)

Papilio priamus admiralitatis Rothschild, 1915, p. 192.

Described from 1♂ and 8♀♀, Manus (Meek Expedition).

Common and widespread, flying throughout the year. Approximately an equal ratio of sexes in the wild. In male, *admiralitatis* totally lacking dorsal green scaling on veins in disc of forewing. On hind wing, above, green scaling denser than in *O. priamus bornemanni* Pagenst, its nearest ally. *O. p. admiralitatis* males rarely lacking golden yellow patch in costal area. In female, according to Rothschild, *admiralitatis* distinguishable from *bornemanni* by shorter, rounder wings and blackish-grey, brighter ground color. Furthermore, pale patches of hind wing extending almost to cell; some specimens with a white spot in cell. On hind wing dark spots in light patches very much larger than in *bornemanni.*

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The author is sincerely indebted to the painstaking work of Mr. R. I. Vane-Wright of the British Museum (Natural History). His efforts concerning the research of the literature has enabled the author to document this article with comparatively rare and pertinent material. In addition, Mr. Vane-Wright has assisted greatly in the development of the final manuscript and certainly without his help this article could not have been completed.

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A NOTE ON "MATING FLIGHT OF BUTTERFLIES WITH MIMETIC FEMALES AND NON-MIMETIC MALES"

My friend R. H. Carcasson's note under the above heading (1970, *Journ. Lep. Soc.*, 24: 72) caused me to look up my own records; the following may be of interest:

Belenois thysa Hpffr. (Pieridae)—Nyali, 4.vii.70. Male flew.

Acraea encedon L. (Acraeidae)—Kampala, 8.v.49 and 30.vii.49 (two pairs). Female flew.

Euryphene mardania orientis Karsch (Nymphalidae)—Shimba Hills, 31.v.70. Female flew.

Precis clelia Cr. (Nymphalidae)—Kampala, 8.v.49. Female flew.

Hypolimnas misippus L. (Nymphalidae)—Kampala, 8.v.49. Female flew.

Castalius calice Hpffr. (Lycaenidae)—Nyali, 9.vii.70. Female flew.

Both sexes of *A. encedon*, the female of *H. misippus* and the female of *E. mardania* mimic *Danaus chrysippus* L. *P. clelia* and *C. calice* are not mimetic and both sexes of *B. thysa* might be said to mimic *Mylothris*.

My own feeling is that the flying position of mated pairs is more of a family, or possibly subfamily, characteristic, and has no direct relationship with mimicry.

D. G. SEVASTOPULO, *P. O. Box 5026, Mombasa, Kenya.*

SOME RECORDS OF *EURISTRYMON ONTARIO* (LYCAENIDAE)

Euristrymon ontario ontario Edwards is rare enough in eastern North America that any captures deserve to be put on record, particularly when the associated environmental circumstances also can be given.

On the basis of what little habitat information I had, the shale barrens of the mid-Appalachians seemed to be an appropriate place for this little-known species. An opportunity to look for it there came in June 1968 when my wife and I drove from Florida to Pittsburgh. We planned our route to cross the Appalachians in Virginia at a point where shale barrens were known to occur, and on 14 June we stopped in the late afternoon to collect in a typical barrens area in Alleghany County, Virginia, near Clifton Forge. Between 4 and 6 PM EDST I took five nearly fresh specimens of *ontario*.

All were on the newly opening flowers of Dogbane (*Apocynum cannabinum*)

which grew in a large, dense stand on a steep, east-facing slope of road fill, the rays of the late afternoon sun just grazing the plants. Only a few feet away was a low, open forest of hard pine and oaks. One of the latter, *Quercus ilicifolia* (or *marilandica*), is a low shrubby species that may possibly be the larval foodplant of *ontario*. Also taken at the same time and place were: *Satyrium calanus falacer* Godart (2♂, fresh), *S. liparops strigosum* Harris (1♂, fresh), both taken on Dogbane; *Achalarus lyciades* Geyer (fresh) and *Thorbyes* (apparently both *pylades* Scudder and *bathyllus* Smith), on the flowers of Viper's Bugloss (*Echium vulgare*); *Epargyreus clarus* Cramer and *Speyeria cybele* Fabricius, both on a single plant of Common Milkweed (*Asclepias syriaca*) growing among the Dogbane. A pair of rather worn *Hesperia sassacus* Harris was also taken.

My favorite shale barrens area is in Green Ridge State Forest, Allegany County, Maryland. Rumor has long had it that *ontario* occurs here, and the general habitat is similar to the Virigina locality. So as soon as possible after we reached Pittsburgh, and armed with my newly augmented knowledge of the environmental choice of *ontario*, my wife and I headed for Green Ridge and spent a day (22 June 1968) looking for it, but absolutely in vain.

The next year, 1969, I was unable to visit Green Ridge at the right time, but in 1970 I went there again and spent 19–20 June combing the area carefully over a wide range of possible habitats. On the 19th I found none at all, even though several of the places searched seemed ideal. But on the 20th my luck changed: in three different locations I took a total of four specimens, all rather worn.

These captures were as follows. (a) "Boy Scout Meadow" [my term]: one each in two different stands of Dogbane, a moderate-sized stand at least 50 feet from the forest, and a large stand immediately adjoining the forest; the forest is low and open, dominantly hard pine with oak and hawthorn admixed, in the valley of Fifteen-Mile Creek (elevation 790 ft.); (b) Sugar Bottom Road: one on the white flowers of Wild Quinine (*Parthenium integrifolium*) along the roadside at the edge of a tall, fairly dense forest of mixed pine, oak and probably hickory along the crest of a ridge (elevation 940 ft.); on the other side of the road was a large cut-over area of stumps, low shrubs and forbs; (c) White Sulphur Community Pond: one on flowers of Dogbane growing in a moderate-sized stand about 25 feet from the edge of a low forest of pine and oak (elevation 750 ft.). *Quercus ilicifolia* is a common species in the Green Ridge area and formed part of the forest in several of the above areas, perhaps all of them. In addition to *ontario*, 28 species of butterflies were taken during these two days. The more significant of these are: *Limenitis arthemis astyanax* Fabricius (the commonest butterfly at the time); *Epargyreus clarus* (common, on flowers of both Dogbane and Viper's Bugloss); *Speyeria cybele* (rather common, on flowers of Dogbane and Butterfly Weed, *Asclepias tuberosa*); *Achalarus lyciades* (one only); *Satyrium calanus falacer* and *S. liparops strigosum* (both somewhat worn, on Dogbane, *falacer* much the commoner and also on leaves at woods edges); *Chlosyne nycteis* Doubleday (fairly common and fresh); *Thorybes pylades* (worn). *Lethe portlandia anthedon* A. H. Clark was just beginning to appear (only a single specimen was seen), as was *Pompeius verna* Edwards.

Our preparator, Mr. John Bauer, has long been interested in *ontario*, and after I had brought back the Maryland specimens he went out to try his luck, despite the already late date. On 28 June, the first day with favorable weather, he went west of Pittsburgh and at a spot near the common boundary point of Allegheny, Beaver and Washington Counties he took a single, much worn specimen, a new species record for Pennsylvania. Western Pennsylvania is an area of essentially deciduous forests of various kinds, and this locality is in a small area of mixed maple and White Oak forest; it is quite different from the Virginia and Maryland localities. His single specimen was taken on the flowers of Common Milkweed. At the same time and place Mr. Bauer also took *Satyrium calanus falacer* (common, somewhat worn, on

leaves), *S. liparops strigosum* (somewhat worn) and *Harkenclenus titus* Fabricius (fresh) (the latter two on Butterfly Weed), a single female of *S. acadica* Edwards (on milkweed), along with *Chlosyne nycteis* (fresh), *Polites peckius* Kirby and *Pompeius verna* (both fresh), *Lethe portlandia* (fresh) and *Thorybes pylades* (very worn).

These several records of *ontario* permit some generalizations on habitat and flight period that may be of help to others in searching for it. Proximity to a forest, preferably low and rather open, of hard pine (*Pinus virginiana* is probably the species most often involved) and oak (*Quercus ilicifolia* presumably one of them) is a common factor for most of the records. So, too, is a nearby open meadow, or other suitable open area, where Dogbane grows. Dogbane seems to be by far the most favored food flower, although single captures in Green Ridge and in Pennsylvania indicate that other flowers may occasionally be visited. Dr. C. F. dos Passos informs me that Dogbane is the favored food flower of *ontario* in New Jersey, and Professor Ernest M. Shull makes the same observation for northern Indiana.

In view of the condition of the specimens and their dates of capture I would estimate that normally the flight period of *ontario* in the Virginia-Pennsylvania region begins on the 10th to 15th of June (possibly a little earlier) and lasts no more than about 20 days, an exceptionally short flight period for a butterfly. The 15th-20th of June seems to be about the optimum time for seeking it in reasonable numbers and in good condition. It appears just about when *Hesperia sassacus* is ending its flight, perhaps about 10 days after *Thorybes pylades* has begun to fly, and just before the appearance of *Speyeria cybele*, *Satyrium falacer*, *S. liparops* and *Lethe portlandia*.

E. ontario is always uncommon, and usually rare. Perched on Dogbane flowers it is usually not reliably distinguishable from *falacer* or *liparops* which occur with it. In the Green Ridge area I searched approximately 15 moderate to large-sized stands of Dogbane and found *ontario* in only three. In its daily behavior it may resemble *falacer* in making use of the forest for roosting at night, and perhaps for mating, but feeding much of the day at flowers usually in nearby fields or other open areas.

The records discussed above may be summarized as follows:

Virginia: Alleghany Co.: 4 mi E of Clifton Forge, on Va. 42 about ½ mi N of jct. with US 60; 14.vi.1968, 3♂ 2♀ (H. Clench).

Maryland: Allegany Co.: Green Ridge State Forest, 6 mi E of Flintstone, 20.vi.1970 (H. Clench): (a) "Boy Scout Meadow" on Fifteen-Mile Creek Rd. about 1.5 mi N of US 40, 1♂ 1♀; (b) Sugar Bottom Road, ca. 1 mi S of US 40, 1♀; (c) White Sulphur Community Pond, ca. 2 mi S of US 40, 1♀.

Pennsylvania: Allegheny Co.: Murdocksville, ca. 3 mi WNW of Clinton, about at common point of Allegheny, Beaver and Washington Cos., 28.vi.1970, 1♂ (John Bauer).

HARRY K. CLENCH, *Carnegie Museum, Pittsburgh, Penna.*

SHAPIRO COLLECTION AT CORNELL

The Arthur M. Shapiro collection of about 13,000 mounted and determined Rhopalocera has been placed in the Department of Entomology and Limnology at Cornell University. It includes 9436 specimens (108 species) from upstate New York and Pennsylvania, of which highlights include long series of all the northeastern *Lethe* (including the newly recognized species, *L. appalachia*), *Limenitis arthemis/astyanax* intergrades, representatives of the newly discovered *Lycaeides melissa samuelis* population from western New York, the unique McLean Bog, N. Y. population of

Poanes massasoit, and such little-known skippers as *Euphyes dion* and *bimacula*, *Poanes viator*, and *Hesperia leonardus* and *metea*. Shorter series of special interest are *Coenonympha tullia heinemani*, a unique eastern Adirondack *Cercyonis*, *Erora laeta*, *Incisalia* spp., and *Colias interior* from Pennsylvania and Tug Hill, N. Y. Singletons include a hybrid of *Limenitis arthemis* and *archippus* and a gynandromorph of *Pieris rapae*, both taken wild in Tompkins Co., N. Y.

The British series includes 1393 specimens (24 species), of which 558 are of the very strange *Pieris napi*-group taxon from northern Scotland (about 20 localities). There are far-northern Scottish *Lycaena phlaeas*, *Polyommatus icarus*, and *Coenonympha pamphilus*, and a bred gynandromorph of English *P. napi*. *Thymelicus lineola* is represented by examples from both countries, including 116 documenting the spread of this introduced species through central New York since 1968.

Among 1026 butterflies in miscellaneous series are over 200 of a *Colias philodice-eurytheme* hybrid swarm in southeastern Arizona, various mutants of the eastern *Colias*, and a series of *Lycaenopsis pseudargiolus* from the New Jersey pine barrens including extreme *lucia*. Finally, there are 1111 bred Pieridae illustrating genetic and environmental experiments on color and pattern regulation.

L. L. Pechuman, *Cornell University, Ithaca, N. Y.*

SPECIMENS DAMAGED BY CARPENTER ANTS

Even the unseasoned collector is aware of the necessity for protecting specimens in storage or cabinet with paradichlorobenzene or naphthalene, to guard against dermestid infestation. In any closed container, these substances repel all injurious pests. When used in a drying cabinet, specimens on setting boards can also be protected.

When setting boards are not enclosed, however, specimens may be subject to one uncommon pest, the Carpenter Ant, *Camponotus pennsylvanicus*. On one occasion I found my boards swarming with workers of *pennsylvanicus*, and the abdomens of several specimens had been eaten. The setting board grooves were stained yellow beneath the specimens with what may have been a formic acid solution, secreted by the ants to soften the abdomen tissues while feeding.

Since dermestid damage is a slow process, there is little danger of destruction during the relatively short time specimens are on the setting boards. Damage from *C. pennsylvanicus*, however, can occur in only minutes. To prevent its recurrence, I treated the edges of all setting boards with a commercial insecticide having strong residual properties. No further ant damage has been noted since this precaution was taken.

J. B. Wood, *140 Pines Drive, Henderson, Kentucky.*

IRWIN COLLECTION TO ILLINOIS NATURAL HISTORY SURVEY

The writer of this note has donated the bulk of his collection to the Illinois Natural History Survey, Urbana, Illinois. It consists of approximately 3,800 pinned specimens of mostly North American butterflies, with emphasis on the Illinois fauna. A number of species contained in the collection were not previously represented in

the Survey collection by Illinois specimens; four species are represented by the only Illinois specimens known.

Also included are 63 specimens originally in the collection of William Henry Edwards and bearing his holograph labels; of these one is an Edwards syntype. This material was listed and its history discussed in a paper in this *Journal* (Irwin, 1966, *J. Lepid. Soc.* 20: 156–162). It has been extensively studied by F. Martin Brown during his current researches on the Edwards butterfly types (see Brown, 1964, *Trans. Amer. Ent. Soc.* 90: 323–413, and subsequent papers in this series).

With the addition of the Irwin collection, that of the Survey becomes the largest and most complete of Illinois butterflies in existence. The Survey is second only to the Field Museum among Illinois institutions in total holdings of Lepidoptera. The writer is currently incorporating several other individual collections as well as his own into the unified Survey butterfly collection, while the remainder of the Lepidoptera is being curated by Dr. Robert W. Poole of the Survey staff.

The writer plans to continue to collect and study Lepidoptera, and to complete the faunal survey of Illinois butterflies which he and Dr. John C. Downey have been conducting for several years.

RODERICK R. IRWIN, *24 East 99th Place, Chicago, Illinois.*

BOLORIA EUNOMIA LADDI (NYMPHALIDAE) IN COLORADO

On 5 July 1967, John Sorensen of Waterloo, Iowa, Pat Conway of Chicago and I collected a small series of *Boloria eunomia* (Esper) in a willow bog just above 10,000+ feet in Gunnison County, Colorado. After examination, these specimens appear to belong to the "Wyoming" subspecies, *laddi* (Klots), rather than to the "Colorado" subspecies, *caelestis* (Hemming). They agree with the *laddi* phenotype by having dark, red-brown coloration on the basal area of the underside of the hind wing and on the subapical patch on the underside of the forewing; rather than the light, yellow-brown coloration of *caelestis*. Their appearance on the upperside does not differ from either *laddi* or *caelestis*. I have no hesitation in assigning them to *laddi*, even though they are separated from Wyoming populations of this subspecies by considerable distance.

Other than a record by Scott Ellis (19 July 1964, also Gunnison County), these are the only known examples of *eunomia* from west of the continental divide in Colorado. I suspect that the *laddi* phenotype will be found to occur along the western slope in Colorado, while the *caelestis* phenotype will be endemic to the Colorado eastern slope.

JOHN H. MASTERS, *Lemon Street North, North Hudson, Wisconsin.*

FLIGHT PATTERN OF THE MALE OF *ANISOTA VIRGINIENSIS* (CITHERONIIDAE)

A colony of fourth-instar larvae of *Anisota virginiensis* (Drury) was found feeding on Water Oak, *Quercus nigra* (L.), early in July, 1970, about seven miles north of McClellanville, South Carolina. The larvae were reared successfully to pupation. About half a dozen mature larvae were preserved by both inflation and vacuum freeze-drying. The authors were especially interested in rearing this species through

to the adult stage for, contrary to the usual pattern, their collection contains a series of females all caught in light traps, but there is not a male in the crowd. A search of the literature working backward from Lutz and Holland through Seitz, Packard, McDunnough, Forbes, etc., revealed a multitude of descriptions and lots of lovely plates and figures of the males and females, but nowhere an answer to the evident dislike of males for our light traps. It was a chance question during a visit by Drs. D. C. Ferguson and J. G. Franclemont that began to shed some light on the mystery.

"Aha," they said in unison. "It's no wonder. Males of *virginiensis* are crepuscular and don't fly after dark!" And so we waited while our twenty-one pupae ticked along. On 21 July a female emerged early in the morning and within one week the whole lot had proved viable and had emerged; there were about equal numbers of males and females. Without exception both sexes emerged soon after sunrise and were expanded and ready for flight by about 9 AM, EST. They were in a screen wire cage on a sheltered porch outdoors, and we killed and mounted all the males as soon as they were dry enough (except for one which escaped with remarkable rapidity). The females, which remained quite docile, were left alive in the cage in hopes that they would attract wild males in the late afternoon and thus prove the crepuscular theory. In vain we sat and watched until it was too dark to see, and again the following mid-afternoon till dark. The next morning about eleven o'clock one of us (CRE) happened to pass by the cage and in utter astonishment saw a very swift red object buzzing rapidly about. A hasty grab for a handy net, and a wild male *virginiensis* was bagged. The following day about noon one of our wives who maintains a close interest in our odd activities reported the same phenomenon. She likewise grabbed the nearby net but failed in the capture. Thereafter we ceased our fruitless afternoon and evening vigils and instead stood watch from sunrise on. In three days, before our last female died her natural death, we caught thirteen more wild males, all between 10 AM and 1:30 PM, EST. They fly rapidly and erratically, reminding one of fast skippers or small Sphingidae, often stopping to hover nearby for a moment and then darting off again. Patience is required of the stalker; wild mid-air sweeps of the net are generally disasterous, but the temptation tantalizing. Thus the actual number of males attracted may have exceeded those captured. The wild males we did capture were almost without exception fresh and in good condition. We did not mate any of the females, and found their natural infertile adult life to be about five days.

One strange and so far unexplained incident occurred. On two occasions a flying object paid a swift passing visit to the caged females. We should have believed it to be *virginiensis* by size, speed and flight pattern but it was dark in color, not the typical deep red of *virginiensis* which is very conspicuous in flight. The first of these UFO's zipped away too fast for identification, but it bore resemblance to the second which hovered at the cage just long enough for positive identification as *Amphion nessus* (Cram). While the latter is a common day-flier in this area, it certainly bears no close relationship to the *Citheronidae*, and its attraction seems a mystery.

Richard B. Dominick and Charles R. Edwards, *The Charleston Museum, Charleston, South Carolina.*

BOOK REVIEW

MARIPOSAS DE VENEZUELA. By Michael Schmid and Bradford M. Endicott. 1968. xi + 67pp., 142 color illus. Publisher: L. Levison Junr., Copenhagen. [available in U.S. from Entomological Reprint Specialists, P.O.Box 207, East Lansing, Michigan; price $9.95]

This, the first book ever to treat Venezuelan butterflies, is, as it should be, in Spanish; but, fortunately for the North American reader, contains a complete English text in the back. The 142 colored plates are excellent. Those species depicted were undoubtedly chosen for their beauty, but still comprise a characteristic representation of the Venezuelan fauna. All but a very few, e.g. *Morpho* species and *Agrias narcissus*, are species that occur in the populated Venezuelan coastal plain.

The commentary on each species is brief but interesting and easily read. The English text is not an exact translation of the Spanish but in a few places has been adjusted slightly for an English audience as, for instance, in the addition of a few English vernacular names. It is easy to fault the book for the outdated nomenclature used, most of which dates back to Seitz. I found 38 of 113 butterflies placed in a taxonomically incorrect genus. A table of "recent name changes" in the back of the book corrects ten of these, but another seven are changed to still another improper usage.

This book is an introduction to Venezuelan butterflies and not a definitive study of them. For the Venezuelan with a casual interest in Lepidoptera or for the North American Lepidopterist with a casual interest in Venezuela, it has a definite place.

JOHN H. MASTERS, *P. O. Box 7511, St. Paul, Minnesota.*

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Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
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by CYRIL F. DOS PASSOS

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Volume 25 1971 Number 2

A REVIEW OF THE GENUS *ARCAS* WITH DESCRIPTIONS OF NEW SPECIES (LYCAENIDAE, STRYMONINI)

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In 1832, William Swainson described *Arcas* as a "subgenus" of the subfamily "Theclanae" (= Theclinae) and established *Papilio imperialis* Cramer as the type species. Yet, most writers throughout the intervening 138 years have neglected to use the name, to identify additional species as belonging to this subgenus or to further define and clarify its status. The purpose of this work is to establish *Arcas* as a valid genus of the *Lycaenidae*, and to separate those species that belong to *Arcas* from the all-inclusive genus *Thecla*.

Arcas, as presently conceived, contains seven species; five heretofore contained in *Thecla* Fabricius, the sixth and seventh described as new. The male of one species, *A. splendor* Druce has been unknown for almost 64 years and is herein described and figured for the first time. Clench (1963) allied *Arcas* with *Atlides* Hübner and *Pseudolycaena* Wallengren. Certainly the three genera share many structural similarities. By the same token, *Arcas* may be readily separated from both by such significant characters as the male scent-spot, the very deep tornal cleft and extraordinarily long tails on the hind wing, and obvious differences in the genitalia of both sexes. All species in the genus are Neotropical. The type species, *A. imperialis* has the widest distribution, being found virtually unchanged in habitus from Mexico south through Panama and throughout South America to southern Brazil and Bolivia (Figure 6).

The following abbreviations are used to indicate the collections from which specimens have been examined and data recorded in this study: (USNM) Smithsonian Institution, Washington, D.C.; (CM) Carnegie Museum, Pittsburgh, Pennsylvania; (AM) American Museum of Natural History, New York; (AF) Allyn Museum of Entomology, Sarasota, Florida; (MN) Museu Nacional, Rio de Janeiro, Brazil; (GS) Gordon B.

Small collection, Balboa, Canal Zone; (PG) P. Gagarin collection in Rio de Janeiro, Brazil; (JD) Dr. John C. Downey collection, Cedar Falls, Iowa; (N) the author's collection.

Genus *Arcas* Swainson, 1832

Type species: *Papilio imperialis* Cramer, 1775

Hind wing with two long tails, the shorter (5 mm) at the end of Cu_1, the second at the end of Cu_2 at least twice as long (10–15 mm); anal angle very deeply cleft forming an elongate, narrow anal lobe. Male with a scent-spot on forewing. Abdomen yellow beneath. Palpi very long, thick, porrect and twice as long as head, curved downward, with all joints entirely covered with close-set mixed blue and black scales. Frons and head covered with brilliant green metallic scales; antennae black, slender, the club scarcely thicker than stalk; eyes with short, obscure bristles.

Male genitalia with the saccus very long, slender, almost twice as long as complete genital ring; ventrally, a pair of pointed, triangular processes extending from the anterior vinculum, and curving partially around valvae; valvae rather compact, broad, about one-half length of vinculum, separated their entire length. Aedeagus very long, longer than combined length of vinculum and saccus, slender, apically flaired and upturned, with two terminal cornuti, one with obscure terminal apical teeth.

Female genitalia with a complex ductus bursae consisting of three distinct sections or elements; entire terminal section of ductus bursae cone-shaped, dorsal plate heavily sclerotized, fan-shaped, relatively wide, smooth-edged, ventral portion membranous near opening, becoming sclerotized at base; mid-section a long, curved, very lightly sclerotized narrow tube; anterior section a sclerotized, widening, recurved complex structure providing entry into corpus bursae; latter a large, rounded sac, adorned by two simple, single-spined signa on inner surface.

As is the case in many *Strymonini* genera, the genitalia of all species in *Arcas* are very similar. Furthermore, the genitalia of both sexes show considerable individual variation within a single species. It would indeed be difficult to separate species in this genus on the basis of the genitalia alone. A ventral view of the full male genitalia with the aedeagus removed is shown in Figure 2, and a lateral view with aedeagus in place is illustrated in Figure 1. With the exception of the valvae, illustrated for each species, no other consistently recognizable differences between species could be found in the male genitalia of the genus. The female genitalia also show considerable individual variation within each species, and a striking similarity among the seven species. Illustrated are ventral views of the complete genital complex for the two new species, a lateral view of *A. ducalis* and a ventral view of the terminal cone-shaped section of the ductus bursae of the remaining species.

The male genitalia of *Arcas* species, although somewhat similar to those of the genus *Atlides*, are consistently different in that the latter are more stoutly built, the saccus shorter, broader, the aedeagus heavier, the valvae very much broader, and in some species, joined together near the anterior end. The female genitalia of species in the two genera show little similar-

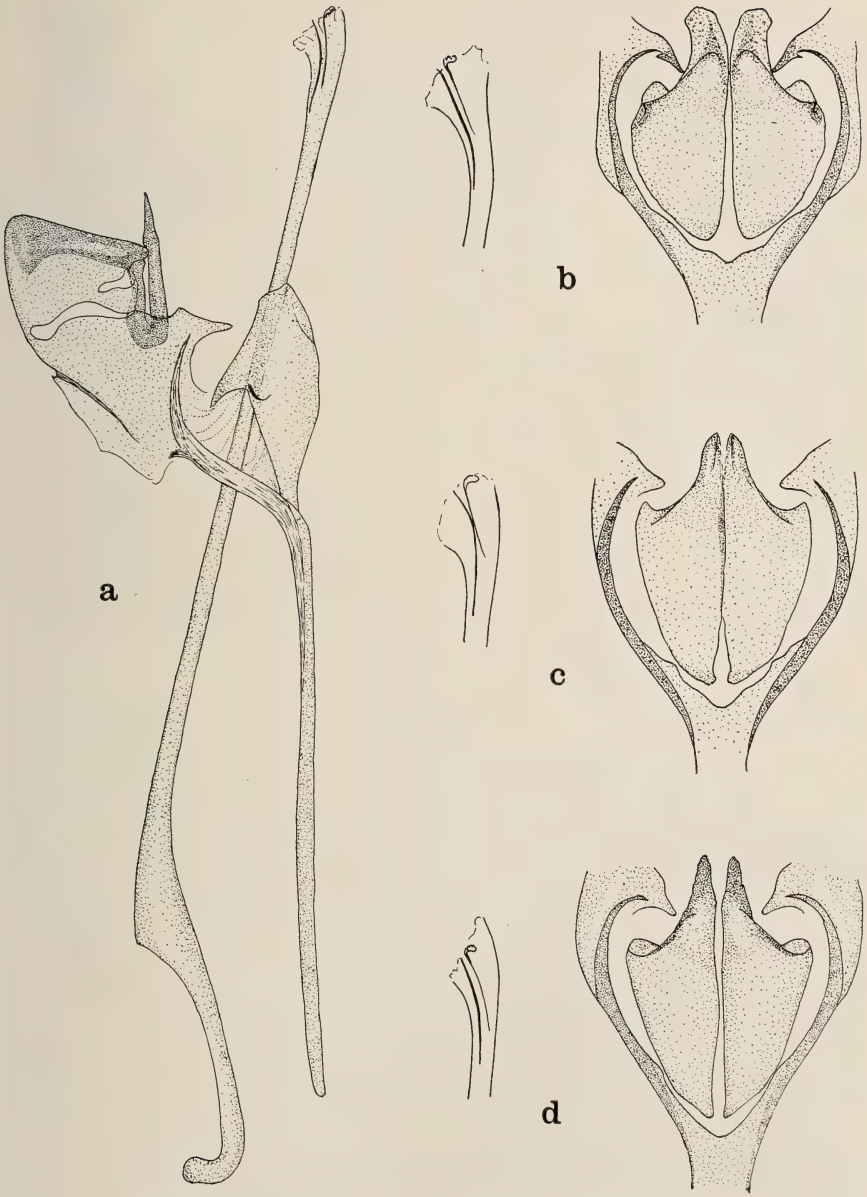


Fig. 1. Male genital structures of *Arcas* Swainson. a, Lateral view of complete genitalia of *A. jivaro* Nicolay; b, ventral view of valvae and lateral view of terminal end of aedeagus of *A. imperialis* Cramer; c, same views and structures of *A. ducalis* Westwood; d, same views and structures of *A. cypria* Geyer.

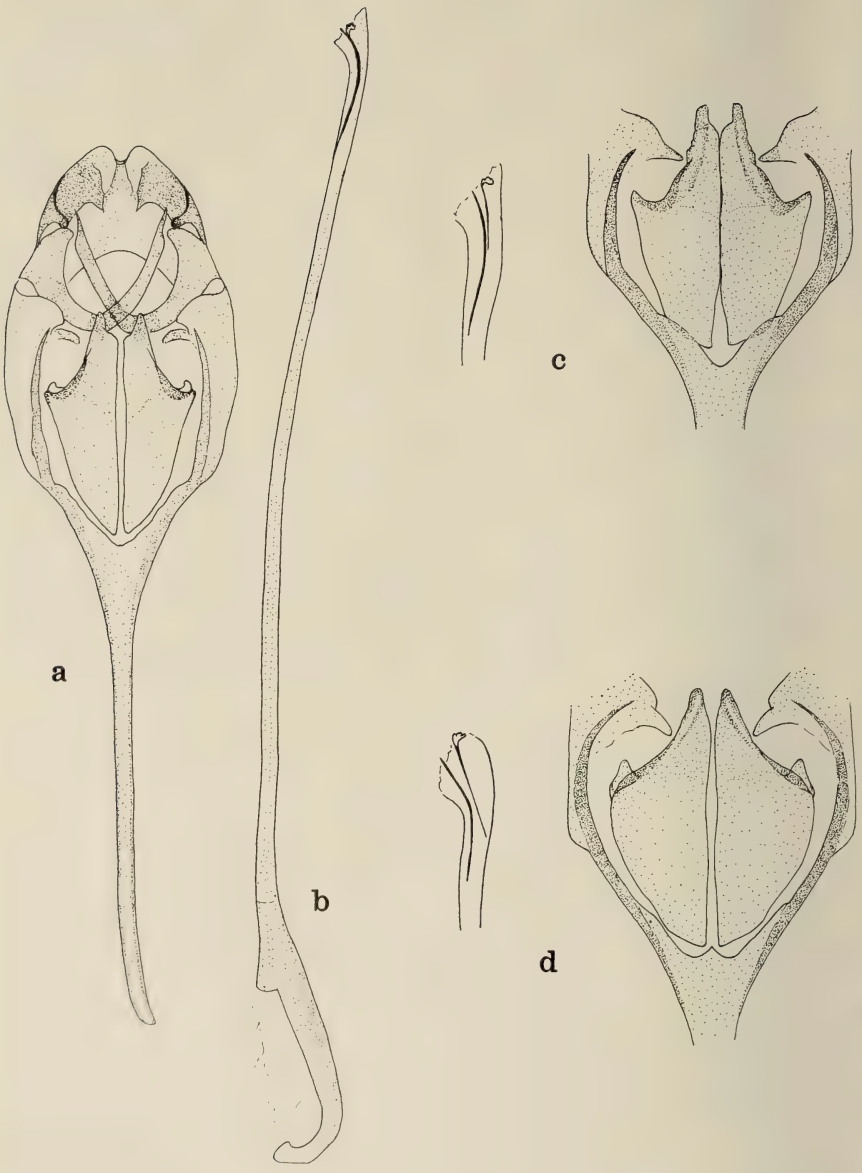


Fig. 2. Male genital structures of *Arcas* Swainson. a, Ventral view of genitalia with aedeagus removed of *A. delphia* Nicolay; b, lateral view of complete aedeagus of *A. delphia* Nicolay; c, ventral view of valvae and lateral view of terminal end of aedeagus of *A. tuneta* Hewitson; d, same view and structures of *A. splendor* Druce.

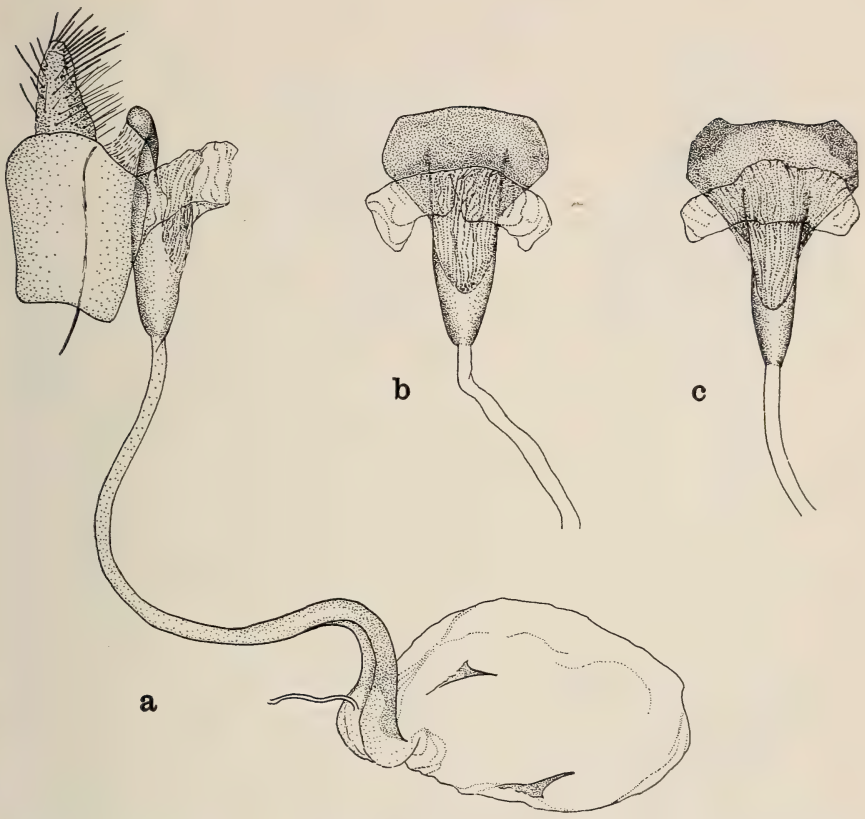


Fig. 3. Female genital structures of *Arcas* Swainson. a, Lateral view of complete genitalia of *A. ducalis* Westwood; b, ventral view of above genitalia, showing terminal, cone-shaped portion of ostium bursae with its fan-shaped dorsal plate; c, ventral view of the terminal portion of the ostium bursae of *A. imperialis* Cramer.

ity. In contrast to the smooth-edged dorsal plate and long, curved, complex ductus bursae in *Arcas*, species in *Atlides* have a ductus bursae with a spined dorsal plate and a heavily sclerotized, simple straight tube entering directly into the bursa copulatrix. The two genera are similar in that both have a pair of single-spined signa on the interior surface of the bursa copulatrix.

The male genitalia of *Arcas* show consistent and obvious differences from those of *Pseudolycaena* in the size, shape and structure of the uncus, saccus and valvae. In *Pseudolycaena*, two heavily sclerotized, toothed processes extend from the ventral surface of the valvae but are completely lacking in *Arcas*. Female genitalia in the two genera differ in many respects, but primarily in the shape and length of the tubular ductus bursae

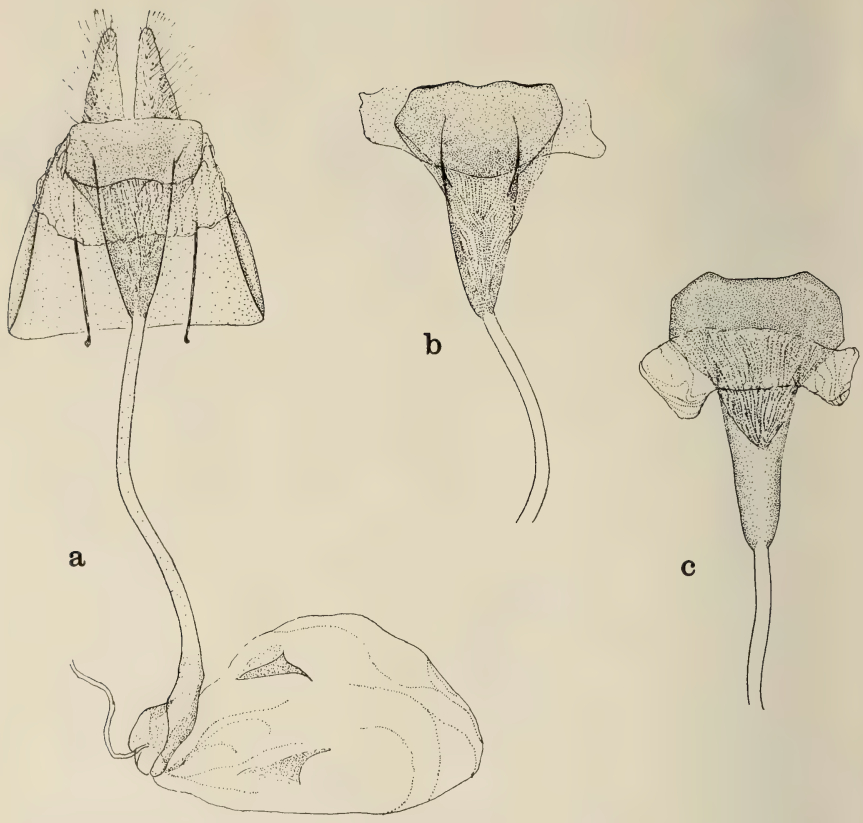


Fig. 4. Female genital structures of *Arcas Swainson.* a, Ventral view of complete genitalia of *A. delphia* Nicolay; b, ventral view of terminal section of ostium bursae of *A. tuneta* Hewitson; c, ventral view of the terminal section of ostium bursae of *A. cypria* Geyer.

which, in *Pseudolycaena* is heavily sclerotized, simple, and relatively straight, emptying directly into the bursa copulatrix, in contrast to the very complex, curved and recurved structure in *Arcas.* Both genera have a bursa copulatrix adorned with two single-spined signa.

Arcas contains some of the most lavishly formed and strikingly colored butterflies in the Neotropics. Eagerly hunted by most collectors, many of the species are still not common in collections. Generally, they are "hill-toppers," in that the males can be found at the summit of the highest point of land within a given area. This trait, combined with a preference for a lofty tree perch makes for a difficult catch at best. Nothing is known of their life history. Some species are true rarities. All collections I have

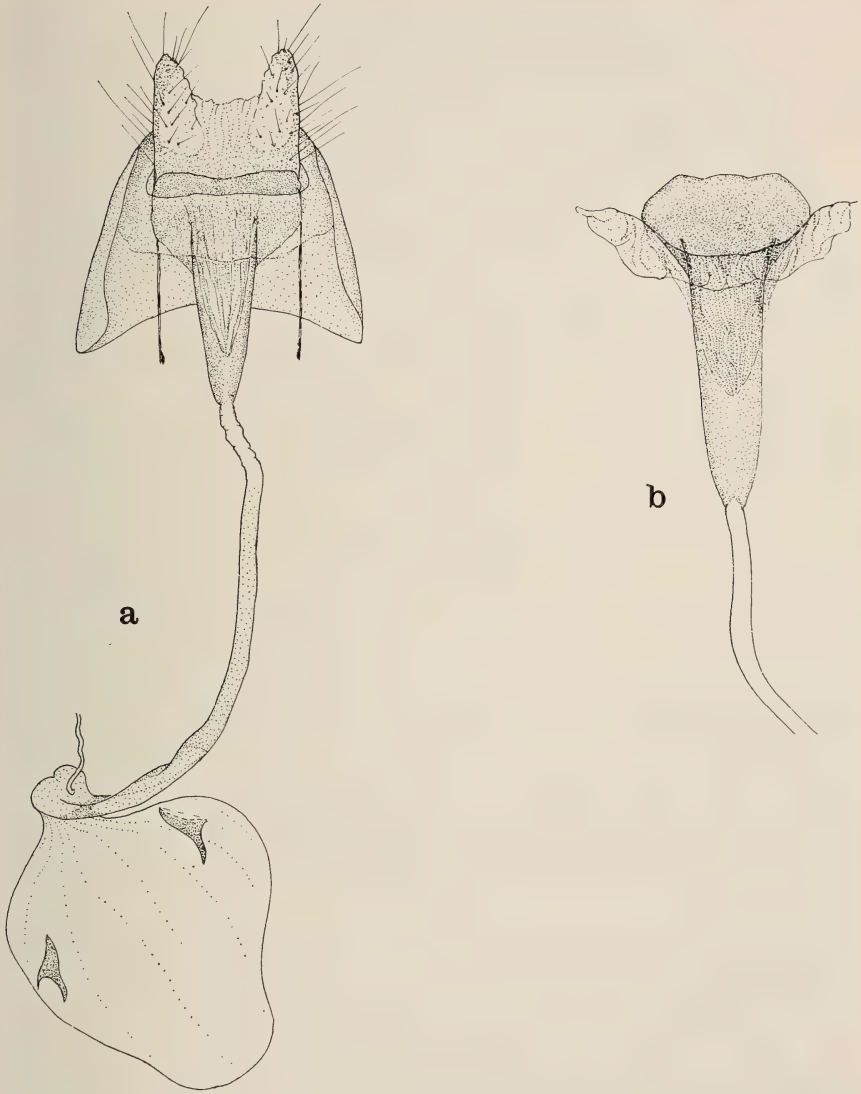


Fig. 5. Female genital structures of *Arcas* Swainson. a, Ventral view of complete genitalia of *A. jivaro* Nicolay; b, ventral view of terminal section of ostium bursae of *A. splendor* Druce.

studied contained relatively few specimens of *A. tuneta* and *A. delphia*, with the latter always included within the series of *tuneta*. The type and allotype of *A. jivaro* are the only specimens known. *A. splendor* remained "uncollected" for well over 100 years until finally discovered again by



Fig. 6. Distribution of species of *Arcas*. Solid circles, *A. imperialis* Cramer; open circles, *A. cypria* Geyer; half-solid circles, *A. delphia* Nicolay; up-right solid triangles, *A. ducalis* Westwood; inverted solid triangles, *A. splendor* Druce; open circle with slanted line, *A. tuneta* Hewitson; inverted solid triangle on line, *A. jivaro* Nicolay.

Gordon Small in 1964. The species is still known from only two rather isolated localities in Central America.

Key to the Species of *Arcas*

1 Underside hind wing without a median line 2
Underside hind wing with a median line 3

2 Hind wing underside brilliant metallic green, striated with black (females from Colombia, Panama and Central America perhaps with a pink wash on disc) *A. imperialis* (Cramer)
Hind wing underside brilliant metallic green, with a clearly defined carmine disc and wide yellow-gold outer wing margin *A. ducalis* (Westwood)

3 Upperside of forewing, male with scent-spot tiny, located well outside the cell, not touching transverse vein; female upperside with dark margins of both wings very wide *A. delphia* Nicolay

Upperside of forewing, male with scent-spot touching or bisected by the transverse vein 4

4 Underside of hind wing with median line bent sharply distad at vein M_3 before curving irregularly to the inner margin *A. cypria* (Geyer)

Underside of hind wing with median band not bent distad, but straight or slightly concave to interspace Cu_2 5

5 Upperside of forewing blue, male with scent-spot large, crossing the transverse vein into the cell 6

Upperside of forewing green, male with scent-spot small, lying outside the cell, touching the transverse vein; female with dark outer wing margins relatively narrow *A. tuneta* (Hewitson)

6 Upperside of forewing, male with scent-spot sharply defined, tear-drop shaped with the proximal point inside the cell; female with underside of forewing with a dark post-median line; the largest species in the genus *A. splendor* (Druce)

Upperside of forewing, male with scent-spot filling distal half of cell extending beyond transverse vein, vaguely defined with a greenish halo; female with no post-median line on underside of forewing *A. jivaro* Nicolay

Arcas imperialis (Cramer)

Figs. 1b, 3c, 7A, 7B, 10A.

Papilio imperialis Cramer, 1775, p. 120; pl. 76, figs. E, F.
Papilio venus, Fabricius, 1781, p. 115.
Theritas venus, Hübner, 1819, p. 80.
Arcas imperialis, Swainson, 1832, p. 88.
Eucharia imperialis, Boisduval, 1870, p. 14.
Thecla imperialis, Hewitson, 1877; 1: 71. Godman & Salvin, 1888; 2:13, 3; tab. 48, figs. 15 and 16. Draudt *in* Seitz, 1921; 5: 748, pl. 146c. Comstock & Huntington, 1960; 68: 234.
Thecla oakesii, Butler, 1884; 14: 267.

"Above shining blue: beneath emerald-green, marked with minute black waved lines. . . It is impossible to depicture with correctness, the resplendant blue which ornaments the upper surface, or the vivid emerald green on the underwings, of this rare and splendid insect."

Little need be added to the above quotation from Swainson's remarks as he described the type species, Cramer's *P. imperialis*. It is a favorite species for color illustrations, and would be difficult to confuse with any other lepidopterous insect.

The black apical border on the upper forewing is large and is more sharply defined in *imperialis* than in other species in the genus. The dark, red-brown scent-spot on the male forewing is placed at the cell end, half in and half outside the cell, the transverse vein clearly marked by a line of brilliant blue scales (Fig. 10A).

Imperialis has a wide geographical distribution from Mexico southward through Panama and through South America to southern Brazil and Bolivia.

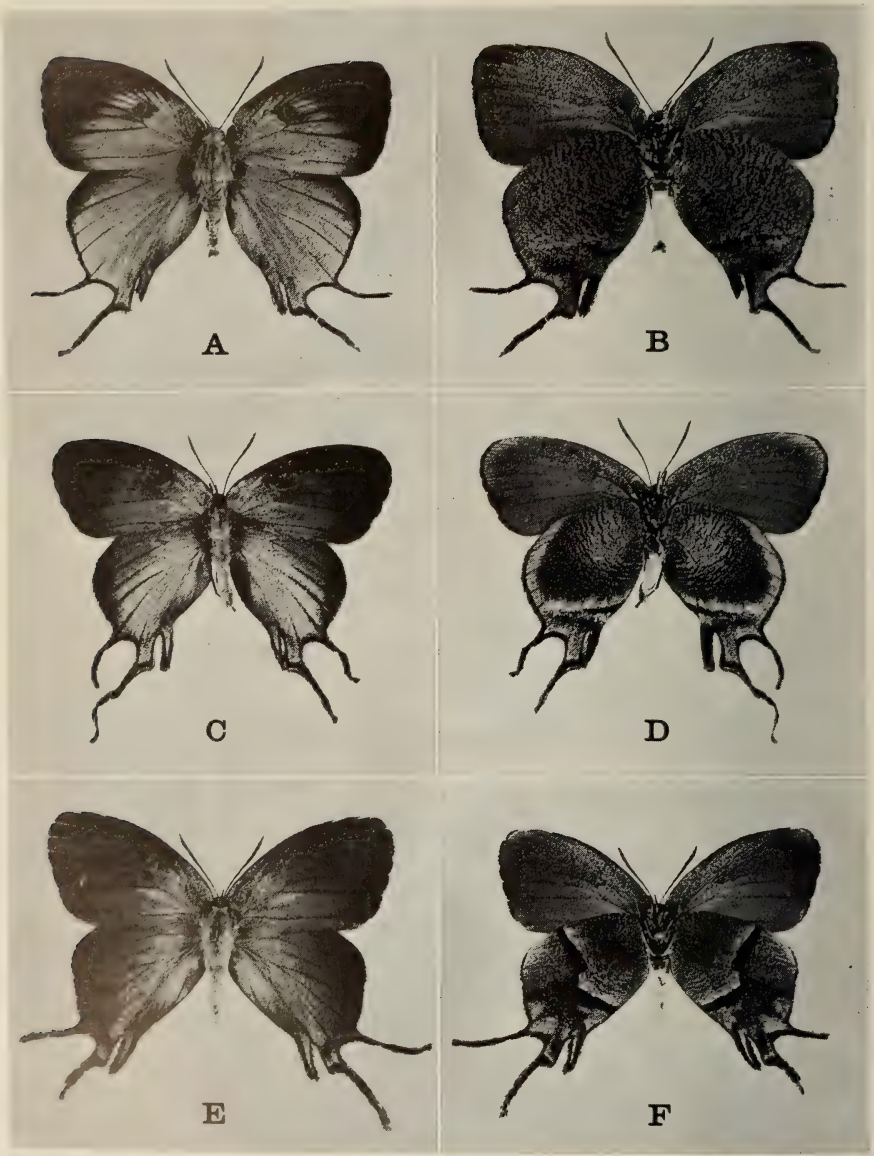


Fig. 7. *Arcas* spp. A, *Arcas imperialis* (Cramer) ♂, Rio Bodoquero (1300 ft.) Caqueta, Colombia, 19 Jan. 1969 (S. S. Nicolay); B, underside of specimen in A; C, *A. ducalis* (Westwood), ♂, Joinville, Santa Catarina, Brazil, 28 Oct. 1967 (O. Mielke); D, underside of specimen in C; E, *A. cypria* (Geyer), ♂, Los Rios, Canal Zone, Rep. of Panama, 29 Jan. 1965 (S. S. Nicolay); F, underside of specimen in E.

Specimens Examined. **Mexico**: *Vera Cruz*—Presidio (USNM, AM) 2♀. **Guatemala**: Cayuga (CM) 1♀. **Honduras**: No locality (USNM) 1♀. **Costa Rica**: Guapiles (USNM) 1♂. Carillo (USNM) 1♂. **Panama**: Bugaba (USNM) 1♂ 1♀. *Canal Zone*—Los Rios, Madden Forest, Summit, Barro Colorado Isl. (AM, GS, N) 10♂ 7♀. **Colombia**: *Cundinimarca*—Bogota (USNM, CM) 2♂. *Magdalena*—Minca (CM) 1♂. *Antioqua*—Casabe (AF, AM) 3♀, Rio Cocorna (AM) 1♀, Medellin (AF) 2♂ 1♀. *Caqueta*—Rio Bodoquero; Tres Esquinas (N) 2♂. *Amazonas*—Rio Tacana (AM) 1♂. *Vague*—Felip Ovalle (AM) 13♂ 8♀. El Centro, Magelena Valley (AM) 2♂. Melgar (CM) 1♂. Yacopi (USNM) 1♀. No locality (USNM, AM, MN) 4♂ 1♀. **Venezuela**: Las Quiguas, Esteban Valley (CM) 4♂. Cucuta (USNM) 1♀. **Peru**: *Loreto*—Iquitos, Putumayo River, Pucallpa, Achinamiza (AM, AF) 16♂ 1♀. *San Martin*—BellaVista, Tarapoto (AM, PG) 2♂. Cusco—La Salud (CM) 2♀. *Amazonas*—Rio Santiago (AM) 1♀. **Bolivia**: Las Juntas, Rio Surutu, Rio Yapacavi, Prov. del Sara, Buenavista, Cuatro Ojos (CM) 14♂ 2♀; Rurrenebaque 1♂ 1♀; San Pedro (AM) 1♂. **French Guiana**: Pied Saut., Oyapok River, No locality (CM) 2♀. **Brazil**: *Pará*—Santarem, Obidos, Utinga (Belem) (AF, MN) 3♂ 2♀. *Amazonas*—Ipiranga, Rio Maues, Manacopuru, Teffe, Rio Solimoes, S. Paulo de Olivenca, Juarete, Rio Negro (CM, MN, AM, N) 13♂ 4♀. *Mato Grosso*—Buriti, Chap. Guimaraes (N) 1♂. *Minas Gerais*—Paracatu (N) 2♂. *Goias*—Jatai, S. Rita Araguaia (N) 2♂. *District Federal*—Parque do Gama (N) 2♀. *Espiritu Santo*—No locality (MN) 1♂. *Rio de Janeiro*—Independencia, Petropolis, Nilopolis, Araruana, Angra dos Reis, Boca do Mato (MN, PG) 5♂ 3♀. *Guanabara*—Gawea, Paineiras, Corcovado, Rio de Janeiro (PG, MN, AF, USNM) 6♂ 3♀. *Sao Paulo*—Mendes, Loreto (MN, AF) 2♂. *Paraná*—Caviuna (AM) 1♀. *Santa Catarina*—Massaranduba-Blumenau, Annaburg, Joinville (MN, USNM, AM, N) 10♂ 4♀. Not located: Colana Island (USNM) 1♂. No data: 1♂ 2♀.

I have taken this beautiful insect in Panama, Colombia and Brazil. Its flight habits and specific haunts are similar in each locality in which I have found it. The male sits perched on a leaf 15–20 feet high above a small sunlight clearing in the heavy forest, whence it makes infrequent and short, swift flights, to return to the same spot. Both sexes may occasionally be found on flowers and, early in the mornings, females at the sunlight edge of the heavy forest on low bushes. Past authors have called it "rare." It is not a common insect, but I would suggest its rarity is due in large measure to its flight habits, for it is difficult to locate and capture.

The name *Thecla oakesii* Butler was given to specimens with a coppery or rosy wash on the disc of the hind wing beneath. Its position in past literature is confusing and variable. Draudt (1921) made it a synonym of *ducalis* Westwood. Lathy (1930) made it a female form of the "Colombian race" of *imperialis*. *T. oakesii* is not a synonym of *ducalis* and I am not at all sure that Lathy's treatment is entirely correct. I have noted that some female *imperialis* taken in localities other than Colombia have varying degrees of the rosy wash on the disc of the hind wing beneath. Of the series of six specimens labeled *T. oakesii* in the National Museum collection, 4 are females, one each from Mexico, Panama, Venezuela, and Colombia. The 2 males, both from Colombia, have a very small and only the faintest indication of pink tint in the disc. The substantial series of

males from Colombia in the American Museum show no pink wash whatsoever; nor do any of numerous specimens I have seen from Panama show this pink wash in the disc. It appears that the amount of rosy tint in the disc on the underside of the hind wing is a highly variable characteristic found primarily in female *imperialis* taken in Colombia, Venezuela and northward into Panama and Central America. The name *oakesii* Butler is not needed.

Arcas ducalis (Westwood)

Figs. 1c, 3a, 3b, 7C, 7D, 10B.

Thecla ducalis Westwood, 1852; 2: 483, pl. 77, fig. 1 (figure only). Kirby, 1879, p. 151. Draudt *in* Seitz, 1921; 5: 746, pl. 146c. Lathy, 1930; 78: 133, pl. 9, figs. 3 and 4. Comstock & Huntington, 1959; 67: 211.

The original figure of this species was published without an accompanying written description. In 1930, Percy I. Lathy wrote concerning the relationship of *ducalis*:

"There has been considerable confusion in collections respecting this species. It is one of those cases where a species has been figured but there is no accompanying description, and as only the upper side is shown the figure might apply to the female of *imperialis* Cram. As a matter of fact Druce took the female of *oakesii*, Btl., a local race of *imperialis* to be *ducalis*. Draudt in Seitz, p. 746, also regards *ducalis* as a race of *imperialis* and places *oakesii* as a synonym. This is incorrect as a glance at the figures . . . will show. *T. ducalis* is a quite distinct species and not a race of *imperialis*, as the two occur together in South Brazil. . ."

The brilliant metallic carmine disc and wide yellow-gold outer margin on the underside of the hind wing are the most obvious macular differences between *ducalis* and *imperialis*. Yet, there are additional and consistent differences between the two. Although the forewing apex in *imperialis* is rounded, it never approaches the extreme foreshortened appearance of *ducalis*; the forewing of *ducalis* is almost elliptical. The male scent-spot in *imperialis* is bisected by narrow blue scaling clearly visible on the transverse vein of the cell end; in *ducalis* the primary scent-spot is unbroken, lying outside the cell, with a tiny group of pale brown scales of a different texture grouped within the cell (Fig. 10B). In *imperialis* the upper hind wing terminal margin is a well defined thin black line, slightly wider at the wing apex; in *ducalis* this margin is vaguely defined and wider throughout the entire wing margin. And although it is a subtle difference, more obvious in males than females, the basic upper side wing color in *ducalis* is a deep blue, without the greenish hues of *imperialis*.

The geographical distribution of *ducalis* is restricted to the states of southern Brazil. At some specific localities within these states, *ducalis* and *imperialis* have both been taken e.g. Independencia near Petropolis, Rio de Janeiro and at Joinville and Umvarana.

Specimens Examined. **Brazil**: *Rio de Janeiro*—Teresopolis; Independencia, Petropolis (MN, PG, USNM, N) 4♂ 2♀. *Sao Paulo*—Umvarana (PG) 1♀. *Parana*—Castro; Londrina; Caviuna (AM, USNM) 3♂ 1♀. *Santa Catarina*—Neudorf; Nova Teutonia; Joinville; Massaranduba-Blumenau (MN, AM, PG, N) 4♂ 8♀. *Rio Grande do Sul*—No locality (MN, AM) 2♂ 1♀.

Arcas cypria (Geyer)

Figs. 1d, 4c, 7E, 7F, 10D.

Theritas cypria Geyer, 1837 *in* Hübner, 1837; 5: 36, figs. 945 and 946.
Pseudolycaena paphia, Felder, 1864–1867; 2: 234, pl. 28, figs. 12 and 13.
Thecla cypria, Hewitson, 1877; 2: 71. Godman and Salvin, 1887–1901; 2: 13, tab. XLVIII, figs. 12 and 13. Draudt *in* Seitz, 1921; 5: 746, pl. 146d. Comstock & Huntington, 1959; 72: 201.

Specimens of this species have been carefully compared with the original description and with the colored plates that accompanied it. The colored figures by Godman and Salvin (1887) are very well done, but the Seitz (1921) figure of the male upperside lacks the scent-spot on the forewing, and the entire figure is done in green rather than the basic blue color of this species on the upper surface. The male dark brown scent-spot is located within the cell with a blue-grey patch of scales of a different texture adjoining outside the cell across the transverse vein (Fig. 10D). The black-brown margin is wide and vaguely defined on both upper wing surfaces.

On the hind wing beneath, a wide black median line, proximally etched in glossy white, begins about mid-costa, is bent distally at vein M_3, then is curved irregularly in an arc to the midpoint of the inner margin. From the median line to the base, the black-flecked brilliant green scaling is washed with a shining coppery-gold. The apices of both fore- and hind wings are dusted in glossy white. The remainder of the hind wing is brilliant green, irregularly dusted with black scaling.

Felder (1867) gave the name *paphia* to specimens of this species with a coppery red disc on the underside of the hind wing. Godman and Salvin (1887) placed *paphia* as a synonym of *cypria*. I agree with this treatment of the name. The series of *cypria* in the National Museum and American Museum collections were taken in a variety of locales from Mexico to Panama. It would be difficult indeed to separate out and designate a subspecies from this group on the basis of a coppery wash on the disc of the underside of the hind wing. Gordon Small and I have both taken this species in various localities in Panama; the intensity and degree of coppery wash seem to vary with individual specimens rather than being the mark of a different species or even a subspecies.

Cypria is essentially a Central American species, ranging from Mexico south to Colombia.

Specimens Examined. **Mexico**: *San Luis Potosi*—Ciudad Valles (CM) 1♀. *Vera Cruz*—Paos San Juan; Coatepec; Presidio; Jalapa; Cordoba City; Misantla (USNM, AM) 8♂ 5♀. *Chiapa*—Tapachula; Palenque (AF, CM, AM) 4♂. *Tabasco*—Terrosique (AM) 3♂. *Yucatan*—Piste 15; Chichen Itza (CM) 8♂ 1♀. *Quintana Roo*—Xcanha (CM, AM) 2♂. **Guatemala**: Cayuga (USNM, CM) 1♂ 1♀. Sayaaxche, El Peten (AM) 2♂ 1♀. **Costa Rica**: Port Limon (USNM) 1♂. Turrialba, Cartago Prov. (JD) 1♂. **Panama**: Chiriqui (USNM, AM) 2♂. Arraijan (AM, N) 2♂. Cerro Campana (GS, JD, N) 3♂ 4♀. *Canal Zone*—Los Rios; Madden Forest; Cocoli (GS, N) 11♂ 1♀. **Colombia**: Medellin (AF) 1♂. El Centro, Magdalena Valley (AM) 2♂ 2♀.

Arcas tuneta (Hewitson)

Figs. 2c, 4b, 8E, 8F, 10E.

Thecla tuneta Hewitson, 1865; 1: 72, vol. 2, pl. 28, figs. 14 and 15. Draudt *in* Seitz, 1921; 5: 746, pl. 146d. Comstock & Huntington, 1961; 72: 177.

The Hewitson (1865) figures are excellent, and the Seitz (1921) illustrations are a reasonable likeness of a female. The upper wing surface of the male is more greenish than any other species in the genus. The black-brown outer margin is only modestly wide on the forewing, beginning at the middle of the costal margin, thence curved out beyond the cell to the tornus and includes the apex and all of the outer margin. The scent-spot is small, inconspicuous, and lies outside the cell, its inner margin touching the transverse vein (Fig. 10E). There is no secondary or adjacent patch of androconial scales. The hind wing margin is moderately broad, black-brown and vaguely defined, and reaches from the apex to the first tail at vein Cu_1. Two black-brown spots lie at the base of the tails.

The underside of the hind wing is dark metallic green, heavily irrorate with black scaling distad to the median line, the inner or proximal half slightly touched with gold scaling. The median line is black and runs almost straight and unbroken from the costal margin to vein Cu_2, then is bent sharply in a short line to the mid-point of the inner margin. Although the median line is slightly concave in *tuneta* and uneven along the proximal margin, it does not break distally at any point as it does in *cypria*.

Tuneta is apparently one of the more uncommon species of this genus. Hewitson states merely that the species is from South America. Near Petropolis, Rio de Janeiro it flies at Independencia where *imperialis* and *ducalis* have also been taken. Bahia is the most northern locality in Brazil whence *tuneta* has thus far been recorded. Dr. Keith Brown took it here on 18 Dec. 1966 at Ubata on the Rio Jequie in a section of deep forest near a hilltop at 300 meters, a location on the rain border between Amazon coastal forest and dry caatinga.

Specimens Examined. **Peru**: *San Martin*—Juanjui; Yumbatos (AM) 1♂ 1♀. Putumayo River (AM) 1♀. **Bolivia**: Rio Surutu; Cuatro Ojos; Portachuelo, Rio

Palmetillas (CM) 3♂ 2♀. **Brazil**: *Bahia*—Ubata, Rio Jequie (KB) 1♂. *Rio de Janeiro*—Independencia, Petropolis (PG) 4♂ 1♀. *Sao Paulo*—No locality (USNM) 1♀. *Santa Catarina*—Joinville; Massaranduba-Blumenau (PG, GS, AM, N) 4♂ 2♀.

Arcas delphia Nicolay, **new species**

Figs. 2a, 2b, 4a, 8A, 8B, 8C, 8D, 10F.

Male. Length of forewing, 19 mm. *Upperside*: Basic wing color brilliant blue-green; forewing margin black-brown, beginning inside midpoint of costal margin, thence curved outside scent spot to tornus, including all of apex and outer margin; scent-spot very tiny, lying completely outside cell, well beyond transverse vein. Hind wing brilliant blue-green with outer margin a thin black line; apex and costal margin vaguely defined, broader, black-brown; a single dark anal spot in interspace Cu_2. *Underside*: Forewing dark forest green, irrorate with sparse black scales, disc pale blue from vein Cu_2 to inner margin; outer margin a thin black line, fringes narrowly pale blue. Hind wing dark, brilliant forest green dusted with sparse black scaling, more heavily so distad of the median line. Median line heavy, black, beginning at costal margin, running almost straight to interspace Cu_2, thence bent sharply at a 90° angle straight to inner margin; outer margin a thin black terminal line from costa to anal lobe. Anal lobe and tails black; fringes pale blue.

Female. Length of forewing, 20 mm. *Upperside*: Forewing blue with a scattering of green scaling, the margin very wide, black-brown running narrowly from base along costa, thence curving around end of cell to tornus. Hind wing blue with a wide, vaguely defined black-brown margin to vein Cu_1; a dark spot in each of interspaces Cu_1 and Cu_2. Anal lobe and adjacent interspace Cu_2 metallic green; fringes black. *Underside*: Forewing dark green irrorate with sparse black intermixed yellow-gold scales; space from vein Cu_2 to inner margin grey-brown; fringes and terminal line, black. Hind wing dark green, with intermixed gold scaling in disc and heavily dusted with black between median line and outer margin; median line slightly concave, bent sharply to inner margin at vein Cu_2; a thin black terminal line running from apex to anal lobe; anal lobe black; fringes narrowly pale blue.

Holotype, male, Guapiles, Prov. Limon, Costa Rica, 850 ft., August (year and collector unknown). *Allotype*, female, Finca la Lola, vic. Madre de Dios, Limon Province, Costa Rica, 21 July 1965. *Paratypes* in the Smithsonian Institution collection: one male, Guapiles, Costa Rica, 850 ft., one male, Yacofsi, Colombia; in the American Museum of Natural History: one female, Costa Rica (no additional data). A single male and three female paratypes in Mr. Gordon Small's collection from the allotype locality were collected on 20–23 July 1965 and a female from Gamboa, C. Z., 25 June 1970. In Dr. Downey's collection are one male and two female paratypes taken at the allotype locality on 19 July 1965; in the author's collection, a single male paratype, Colon (Santa Rita), 1500 ft., Panama, 2 February 1969 and three female paratypes from the allotype locality in Costa Rica. In the Schmidt–Mumm collection in Bogota, Colombia is a male taken at Victoria, Dept. of Caldas in August 1958. The male holotype is deposited in the Smithsonian Institution, Washington, D.C., the female allotype, in Mr. Gordon Small's collection, Balboa, Canal Zone.

It is obvious that *delphia* is closely related to *tuneta*. The genitalia of both sexes are very similar with no apparent recurring or obvious differences. Yet, the location of the male scent-spot, longer hind wing and much reduced dark margins on the upper hind wing of the male *delphia* remain consistent differences between the two species. Females are more difficult to separate, the most consistent difference being the very wide

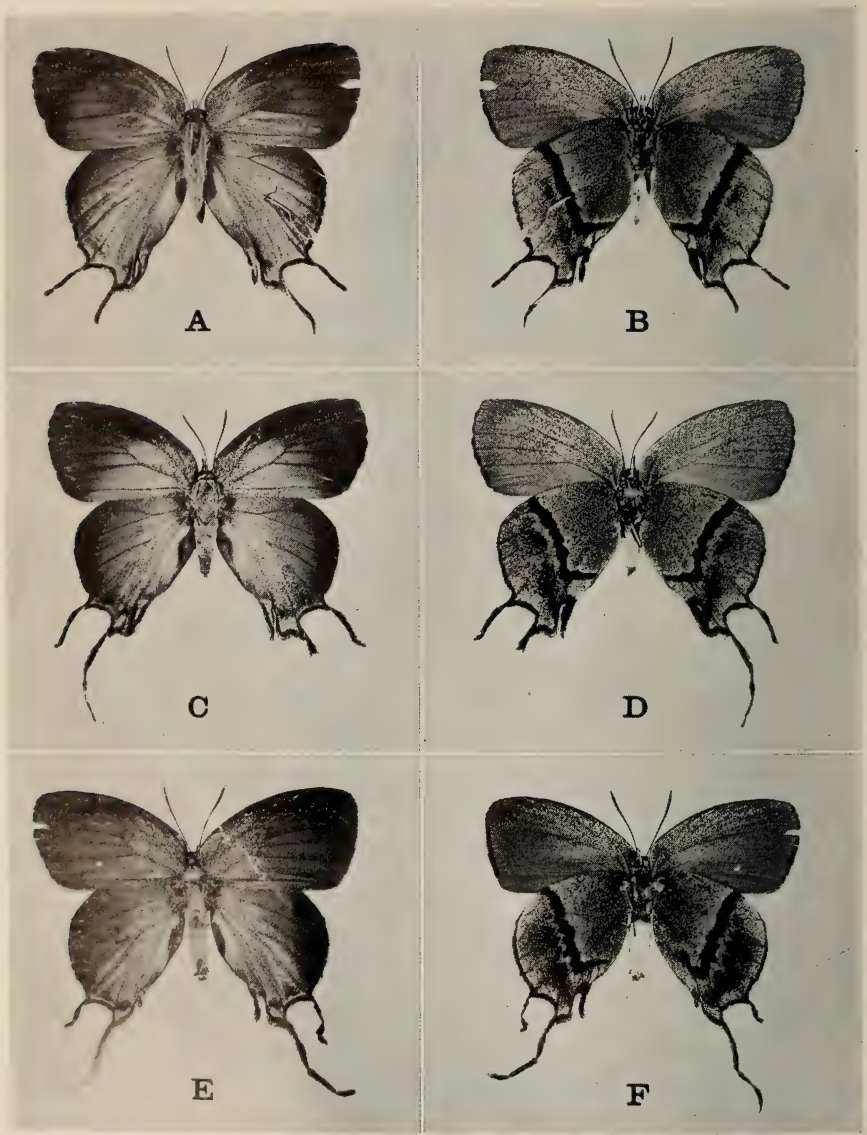


Fig. 8. *Arcas* spp. A, *Arcas delphia* Nicolay, ♂, paratype, Finca la Lola, vic. Madre de Dios, Limon Prov., Costa Rica, 20 July 1965 (G. B. Small); B, underside of specimen in A; C, *A. delphia* Nicolay, ♀, allotype, same locality as paratype in A, 21 July 1965 (G. B. Small); D, underside of specimen in C; E, *A. tuneta* (Hewitson), ♂, Joinville, Santa Catarina, Brazil, 28 Oct. 1967 (O. Mielke); F, underside of specimen in E.

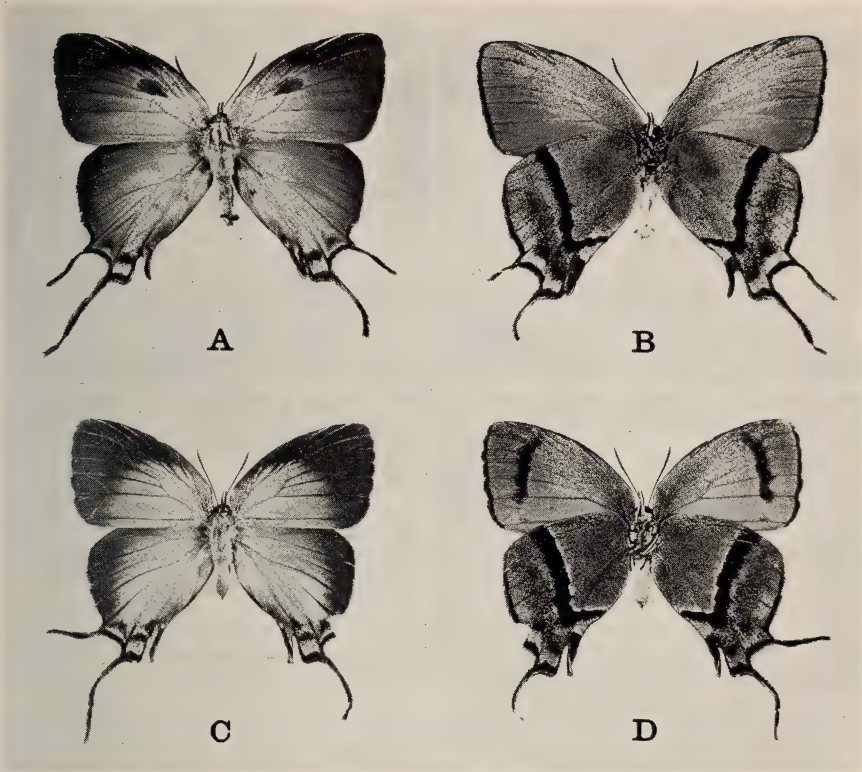


Fig. 9. *Arcas* sp. A, *Arcas splendor* (Druce), ♂, Cerro Campana (2500 ft.), Rep. of Panama, 5 Aug. 1964 (G. B. Small); B, underside of specimen in A; C, *A. splendor* (Druce), ♀, Cerro Campana, Rep. of Panama (2500 ft.) 29 Aug. 1966 (G. B. Small); D, underside of specimen in C.

heavy dark margins on the upper surface of both fore- and hind wings in *delphia.*

Like *cypria*, *delphia* is essentially a Central American species, but obviously quite rare. It has been found no further north that Costa Rica with its southern limits in Colombia.

Arcas splendor (Druce)

Figs. 2d, 5b, 9A, 9B, 9C, 9D, 10C.

Thecla splendor Druce, 1907, p. 570; pl. 31, fig. 4. Draudt *in* Seitz, 1921; 5: 746, pl. 146d. Comstock & Huntington, 1961; 71: 196.

For over 100 years, *splendor* has been known and represented in collections by only Druce's type, a worn female, taken some time between 1848 and 1857. In the summer of 1964, Mr. Gordon Small took a series of

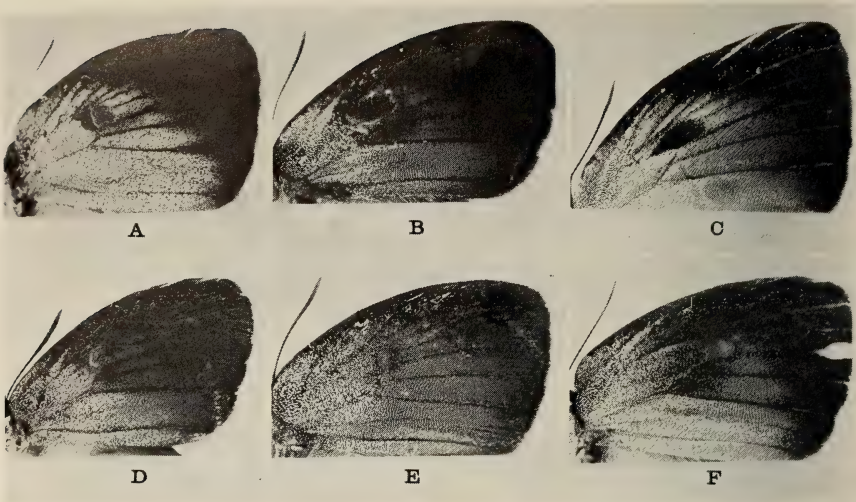


Fig. 10. Upper right forewing of male of *Arcas* spp. showing scent-spot. A, *Arcas imperialis* (Cramer) ♂; B, *A. ducalis* (Westwood) ♂; C, *A. splendor* (Druce) ♂; D, *A. cypria* (Geyer) ♂; E, *A. tuneta* (Hewitson) ♂; F, *A. delphia* Nicolay ♂.

males and females of this species in the Republic of Panama, thus recording for the first time, the capture of a male of this splendid insect. Druce's original description is of interest and quoted herewith:

"Female. Allied to *T. tuneta* Hew. which it closely resembles on the upper side. On the under side it differs in possessing a curved, black, ultramedian band on the fore wing, inwardly edged with whitish, and in the median band on the hind wing being broader, placed further from the base, more concave, and more sharply angled to the anal margin. There is also a submarginal indistinct dark shade which is not present in *T. tuneta* Hew.

"Expanse 1 9/10 inch.

"Hab. Colombia

"Type, Mus Oxford, No. 1901/1198

"Collected 1848–1857 by H. M. Vice-Consul Edward W. Mark, and presented to the Museum in 1901 by Mr. F. W. Mark.

"The type, which is the only specimen I have seen, is not in very good condition, having lost its antennae and abdomen; but enough remains to show that it is a very distinct species, and I believe unnamed."

Male. Length of forewing, 22 mm ± 2 mm. *Upperside*: Forewing brilliant blue with golden-green scaling intermixed; the black-brown margin moderately wide with a vaguely defined inner edge, beginning about mid-costa then curving outside scent-spot to tornus and including all of apex and outer margin; scent-spot tear-drop shaped, large, black brown, placed with proximal point inside cell, remainder of spot outside cell (Fig. 10C). Hind wing of same brilliant blue-green color with a black margin wider at apex, narrowed to a thin black line at tornus, with black spots at tornus in interspaces Cu$_2$ and Cu$_1$. *Underside*: Forewing dark green with scattered black scales, a thin black marginal line and pale blue fringes. Hind wing the same deep green; a thin black median line, slightly concave with a thin white proximal margin, running

from costal margin to mid interspace Cu_2, then sharply bent at 90° angle straight to inner margin. A thin black terminal line beginning at apex and ending at black anal lobe; fringes pale blue. Area between median line and terminal line, heavily smudged and dusted with black.

Draudt (1921) presumed *splendor* to be allied to *tuneta*, referring to it as "probably only a form. . ." I have examined the type in the British Museum, comparing it carefully with color transparencies of specimens collected by Gordon Small in Panama. I have no doubt that the Panama specimens are *A. splendor* and that *splendor* is indeed a valid species. The female of *splendor* is unique in the genus, in that it has a post median line on the underside of the forewing. The male is easily separated from those of other species in the genus by the large tear-drop shaped scent-spot on the forewing. *Splendor* is the largest species in the genus.

It would be impossible at this time to pinpoint the type locality more accurately than "Colombia." Yet, it is worthy of note that Panama was a part of Colombia when Druce's type was collected. The currently known geographic range of *splendor* is limited to Panama and Costa Rica. Here, limited to two specific localities, Cerro Campana (2500 ft.) Panama and Moravia (3500 ft.) Cartago Prov., Costa Rica, it flies in the rain forest that clothes the mountain tops. We have searched but have not been able to find this species during recent collecting trips to many other localities in both Colombia and Panama.

Specimens Examined. **Panama**: Cerro Campana, 2500 ft., Panama Prov. (GS, JD, N) 19♂ 5♀. **Costa Rica**: Moravia, 3500 ft., Catago Prov. (GS, JD) 1♂ 2♀.

Arcas jivaro Nicolay, **new species**

Figs. 1a, 5a, 11A, 11B, 11C, 11D.

Male. Length of forewing, 17 mm. *Upperside*: Basic wing color brilliant blue with a slight greenish cast; forewing dark margin wide, with a well defined inner margin beginning just proximal to midpoint of costa, curved outside cell and scent-spot and then to tornus, including all of the apex and outer margin; the scent-spot large, but vaguely defined, filling distal half of cell, extending out beyond transverse vein and surrounded by a greenish halo. Hind wing the same brilliant blue, with a very narrow dark outer margin, vaguely broader near apex and along costa; a dark narrow bar across anal angle at interspaces Cu_2 and Cu_1. *Underside*: Forewing dark lustrous green with pale-blue scaling in disc above inner margin; outer margin a thin black terminal line, fringes dark grey-blue. Hind wing dark lustrous green, sparsely irrorate with black, most prevalent distad of median line toward anal angle. Median line black, proximally etched with a very thin line of light scales, extending from midpoint of costa almost to cleft of anal lobe, then sharply bent at 90° angle to inner margin. Outer margin a thin black terminal line from vein Rs to anal lobe; anal lobe and tails black, fringes narrowly pale blue.

Female. Length of forewing, 18 mm. *Upperside*: Forewing lustrous blue with a vaguely defined, wide, dark margin beginning just proximal to mid-point of costa then curved around outside cell to tornus. Hind wing lustrous blue with a vaguely defined, dark outer margin, widest just below apex, disappearing at Cu_1; terminal margin a thin black line from apex to anal lobe; anal lobe and adjacent interspace

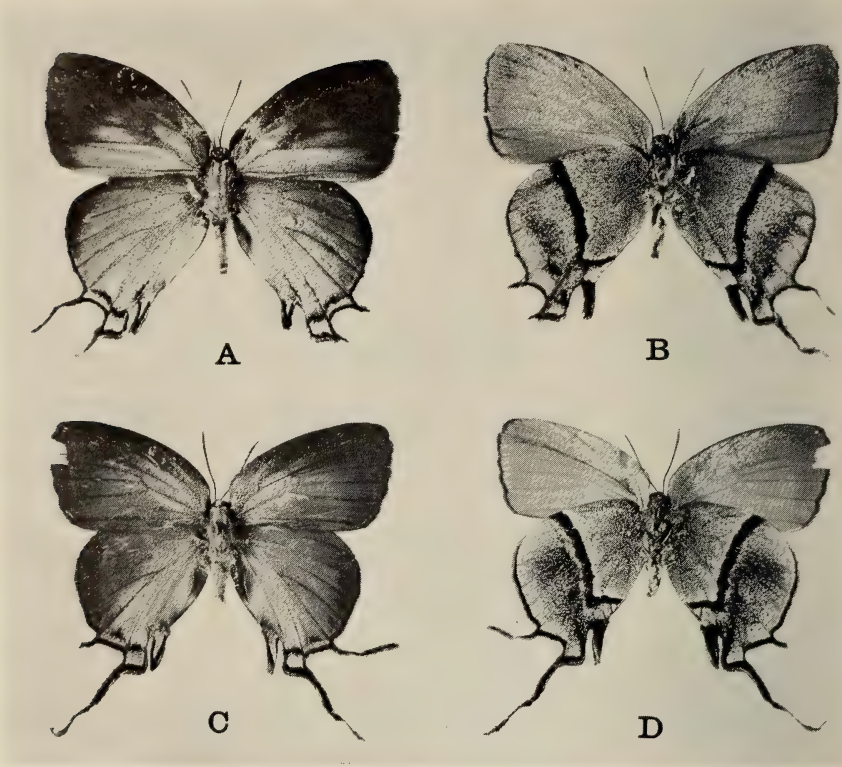


Fig. 11. *Arcas* sp. A, *Arcas jivaro* Nicolay, ♂, holotype, Sucula, Macas, Ecuador (800 m) date and collector unknown; B, underside of specimen in A; C, *A. jivaro* Nicolay, ♀, allotype, same data as holotype; D, underside of specimen in C.

iridescent green. A dark narrow bar across interspace Cu_2, a dark spot in interspace Cu_1, fringes narrowly blue. *Underside*: Forewing lustrous golden-green, disc above inner margin light brown out to and including tornus; terminal line black, thin; fringes brown. Hind wing golden green in disc proximal to median line; dark green heavily dusted and smudged with black just distad of median line toward anal angle. Median line black, etched proximally in white, extending from mid-costa to just above cleft of anal lobe, then curved sharply at 90° angle to inner margin. Anal lobe and tails black; terminal line black, narrowly etched in white from above costa to Cu_1, extending from costa to anal lobe; fringes very pale blue, almost white.

Holotype, male, Sucula, Macas, Ecuador, 800 meters (date and collector unknown). *Allotype*, female, same data. The holotype and allotype are located in the American Museum of Natural History, New York.

Some interesting observations can be made about this species. Among the many dozens of specimens of *Arcas* I have studied, representing most of the major collections in this hemisphere, these are the only two specimens of the genus I have seen from Ecuador. Primarily I presume, this

is due to the lack of collecting and/or collectors in Ecuador. Yet, even *imperialis* is notably lacking in collections. The male of *A. jivaro* displays a rather striking mixture of characteristics found in other species of the genus. The underside of both sexes, but particularly that of the female is similar to *tuneta*. Yet, the upperside of the male is the basic lustrous blue-green of *imperialis*, not the green of *tuneta*. The wide, rather sharply delineated dark wing margins of the forewing are also like those of *imperialis*. The underside of the hind wing is the dark lustrous green of *A. splendor* with a relatively narrow but heavy black median line, also reminiscent of that species. The scent-spot is unlike that of any other species in the genus. The single female is, however, indistinguishable from females of *tuneta*. It is possible that a small series of females of *jivaro* would reveal some consistent and reliable differences.

The presently known geographic distribution of *A. jivaro* is restricted to the type locality, located near the town of Macas, the capital of the Territorial Division of Morona Santiago, Ecuador.

Acknowledgments

I wish to thank a number of people who provided the information and valuable assistance that is so vital to a work of this scope. To Gordon B. Small, Jr., Balboa, Canal Zone and Dr. John C. Downey, University of Northern Iowa, Cedar Falls, Iowa must go credit for the excellent field work which provided the basis for much of the new information contained herein. I am indebted to Dr. Keith S. Brown, Jr., Rio de Janeiro, Brazil who provided a great deal of the distributional data and other helpful information on the material in the Museu Nacional collection.

Mr. T. G. Howarth and Mr. G. E. Tite generously allowed me to examine types in the British Museum. William D. Field, United States National Museum; Dr. F. H. Rindge, American Museum of Natural History; Harry K. Clench, Carnegie Museum and Dr. Lee D. Miller, Allyn Museum of Entomology, provided the assistance and cooperation that allowed me to examine the material in the collections in their care, and offered many helpful suggestions during the course of this study.

The photographs were made by Robert C. Williams, formerly of the U.S. Marine Corps, now at the University of Michigan and Lt. G. G. Thomas, USMC. Their interest, energy and technical competence were especially helpful. Drawings of the genitalia were made by the author.

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AN UNUSUAL VARIANT OF *COLIAS PHILODICE* (PIERIDAE) IN NEW HAMPSHIRE

On October 5, 1970, I took a male *Colias philodice philodice* (Latreille), in Lebanon, Grafton County, New Hampshire. This male is lacking all traces of the smaller of the two ocelli on the underside of the hind wings with the exception of a minute dot of color on the left. A closer examination of the ocelli showed that the larger ocelli were incomplete where they joined vein M_2. An examination of the uppersides of the hind wings showed that the corresponding orange colored spots were incomplete, with the exception of a minute dot of color on the left side.

Due to the completeness of all other *philodice* markings, and also due to the presence of part of the characteristic rings around the parts of the ocelli that are present, there is little or no possibility of this specimen being mistaken for *Colias interior interior* (Scudder.) For reference purposes, this specimen has been deposited in the collection of the Dartmouth College Museum (specimen # DCM-170-37-49355).

RICHARD E. GRAY, *Associate Curator of Biology, Dartmouth College Museum, Hanover, New Hampshire.*

THE LIFE HISTORY OF *SCHINIA CUPES DESERTICOLA* (NOCTUIDAE)

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Canada Department of Agriculture, Ottawa, Ontario

Schinia cupes Grote (1875, p. 113) is distributed from central Texas (Georgetown, Irving) westward to the San Joaquin Valley of California (Shafter, Coalinga), and northward in the Great Basin area to southern Idaho (Twin Falls). On the deserts of southern California it is represented by a paler and less strongly maculate form named *deserticola* by Barnes and McDunnough (1916, p. 5). All of the Texas specimens examined as well as those from the San Joaquin Valley and from southern Idaho are of the typical dark form.

The species is very common on both the Colorado and Mojave Deserts of California, and all of the hundreds of specimens that have been examined from this area are of the pale vicariant *deserticola*. In the rather limited series of genitalic slides examined, the valve of *deserticola* is somewhat narrower and the vesica somewhat shorter than in typical *cupes*. The consistently paler colouring, the less intense maculation, and the slight but possibly constant differences in male genitalic structure may indicate that *deserticola* is actually a distinct though closely related species. A knowledge of the habits and food plant of typical *cupes* will undoubtedly help to clarify the problem. For the present, it seems preferable to retain the existing nomenclatorial status of *deserticola* as a subspecies of *cupes*.

The Texas specimens of *cupes* were taken in April and May, the southern Idaho specimens in mid June, and the San Joaquin Valley specimens in April. Specimens of *deserticola* examined were taken during March and April. In the spring of 1955, the flight at Thousand Palms in the Colorado Desert of California was found to extend from 9 March to 10 April. Three specimens taken at Indio, California on 28 October suggest that pupal diapause in the species may be terminated by the occasional fall rains that occur on the California deserts.

Behaviour

Schinia cupes deserticola feeds in the larval stage on the flowers and seed capsules of *Oenothera clavaeformis* Torr. and Frém. (Figs. 2, 3). Unlike many species of *Schinia* that are protectively coloured in their resemblance to the flowering heads of their food plants, the pale greyish-

fawn colouring of adult *deserticola* bears no resemblance to the reddish-pink flowering head of *Oenothera clavaeformis*. During a period in which the heads of the *Oenothera* were being examined daily for eggs and young larvae, no adults were found resting in the plants. The moth is evidently exclusively nocturnal and the eggs are deposited at night, usually on the still tightly closed buds (Fig. 2). A single wild-caught female deposited a total of 93 eggs.

The newly hatched larva makes its way to the base of the bud and bores through the calyx and corolla to gain entrance to the interior. Both first- and second-stadium larvae feed preponderantly on the fleshy red tissue of the inner surface of the receptacle. This habit is evidently responsible for the pinkish colouring that the larva assumes after a period of feeding. During the third stadium, the larva attacks other sexual parts of the plant. In the fourth stadium the larva usually quits the bud or blossom and feeds from an exposed position on the flowering stem. In the latter part of the fourth stadium and during the fifth, the larva feeds almost exclusively on the younger seed capsules, and the buds are largely abandoned as food. Unlike *Schinia felicitata* and *Schinia florida* which bore through the wall of the seed capsule of other species of *Oenothera* to eat the developing seeds, *Schinia cupes* actually consumes the whole capsule. The more common red and mauve larvae are probably afforded protection from predators by their general resemblance to the pink flowering head of the food plant. All of the individually reared larvae of *deserticola* matured in a uniform five stadia.

The larva tunnels into the soil to form a pupal cell and it is as a pupa in the ground that the species spends the majority of the year.

Description of Stages

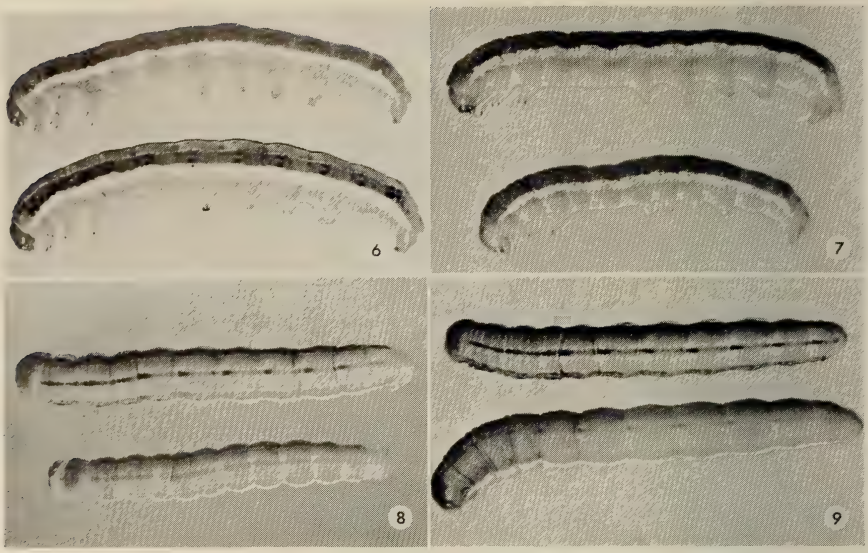
The following descriptions of immature stages are based on the progeny of two females of *deserticola* taken at Thousand Palms, Riverside Co., Calif.; the description of the adult applies only to *cupes deserticola*. Rearing techniques employed were those outlined by Hardwick (1958). The duration of stadia listed are those for larvae reared at room temperature; the estimate of variability, following the mean for various values, is the standard deviation.

Adult (Fig. 1). Head and thorax grey irrorate with brown; abdomen pale fawn-yellow. *Forewing* light fawn-grey. Transverse anterior line white with a dark inner margin, consisting of three shallow excurved arcs. Basal space light fawn and containing a variably expressed white or pale-grey basal line. Transverse posterior line white, broadly excurved around cell, then essentially straight to inner margin; t.p. often weakly scalloped between veins. Median space light grey irrorate with light brown; both reniform and orbicular spots large and prominent, and both with a



Figs. 1–5. *Schinia cupes deserticola* B. & McD. and its food plant. 1, Adult, Thousand Palms, Calif.; 2, eggs on buds of *Oenothera clavaeformis* Torr. and Frém.; 3, *Oenothera clavaeformis* in its typical desert habitat; 4, dorsal aspect of ultimate-stadium larvae; 5, ventral aspect of pupae.

dark central shade; orbicular always circular. A dark median shade or line passing from costa through reniform and then paralleling t.p. line to inner margin. Subterminal line an irregular pale shade, often with intervenal dark sagittate marks proximal to it. Subterminal space fawn. Terminal space usually paler than subterminal space. A series of intervenal dark-brown, marginal lines. Fringe checkered fawn and brown. *Hind wing* dull cream with a broad, smoky-brown, outer-marginal



Figs. 6–9. *Schinia cupes deserticola* B. & McD., ultimate-stadium larvae. 6, 7, Left lateral; 8, 9, dorsal.

band. A pale patch usually evident in median area of outer-marginal band. A brown, discal lunule usually prominently expressed. Veins often outlined by brown scales. Fringe white variably marked with light brown, most strongly so at base. *Underside* of both wings dull pallid cream marked with brown. Forewing with a prominent brown reniform, a small dot-like orbicular, a variably expressed post-median line and a paler, smoky-brown subterminal band. Fringe cream. Hind wing with a brown discal lunule, a variably expressed, usually broken, post-median line and an evanescent outer-marginal band. Fringe cream or white.

Expanse: 29.4 ± 1.2 mm (100 specimens).

Egg. Pale creamy-yellow when deposited and remaining so for the next 24 hours; assuming a slight pink or orange tone on anterior half during second day. Pink tone more pronounced and sharply defined on third and fourth days after deposition. Whole egg turning dark grey with head and prothoracic shield becoming visible through chorion a few hours before hatching.

Dimensions of egg: length, 0.52 ± 0.07 mm; diameter, 0.64 ± 0.03 mm (5 eggs).

Duration of egg stage: 4.4 ± 0.6 days (97 eggs).

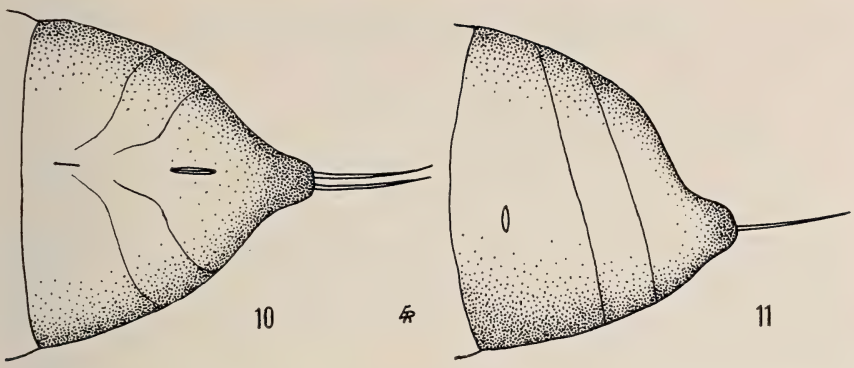
First-Stadium Larva. Head very dark brown or black. Prothoracic and suranal shields dark smoky-brown. Trunk creamy-white or greyish-white and often stained with pink. Thoracic legs and proleg shields smoky-brown.

Head width: 0.31 ± 0.01 mm (25 larvae).

Duration of stadium: 3.6 ± 1.0 days (21 larvae).

Second-Stadium Larva. Head capsule light orange-brown variably suffused and mottled with medium brown. Prothoracic shield pale fawn marked with brown along margins. Suranal shield pale fawn lightly marked with greyish-brown. Trunk greenish-grey or yellowish-grey and often stained with pink; dorsum of trunk with a median and a pair of subdorsal light reddish-brown lines; a pale-cream or greyish-white [illegible] band. Thoracic legs and proleg shields dark smoky-brown.

Head width: 0.53 ± 0.03 mm (25 larvae).



Figs. 10, 11. *Schinia cupes deserticola* B. & McD., apical abdominal segments of pupa. 10, Ventral; 11, right lateral.

Duration of stadium: 2 days (21 larvae).

Third-Stadium Larva. Head light fawn, weakly mottled with light chocolate-brown. Prothoracic shield pale fawn tinged with pink or green. Suranal shield pink or green depending on body colour. Trunk varying from cherry-red through pink and various shades of brown to leaf-green. Mid-dorsal band usually the darkest area of trunk. Subdorsal area paler than mid-dorsal band, and with poorly defined marginal lines of white or cream. Supraspiracular area only slightly paler than mid-dorsal band. Spiracular band light yellow in green specimens, cream or white suffused with pink in red and brown specimens. Suprapodal area concolorous with subdorsal area. Mid-ventral area grey, greenish-grey or pinkish-grey. Thoracic legs cream or very pale fawn.

Head width: 0.92 ± 0.04 mm (25 larvae).

Duration of stadium: 2.1 ± 0.5 days (21 larvae).

Fourth-Stadium Larva. Head cream or pale fawn variably mottled with darker fawn. Prothoracic shield poorly distinguished and suranal shield undistinguished from remainder of trunk. Trunk cherry-red, purplish-brown, chocolate-brown or green. Mid-dorsal band usually somewhat darker than subdorsal area but often poorly distinguished from it; in some cases mid-dorsal band margined by evanescent pale lines. Subdorsal area separated from supraspiracular area by a pale greyish-cream line. Supraspiracular area somewhat darker than mid-dorsal band, lightly flecked with cream or grey. Spiracular band yellowish-cream. Suprapodal area concolorous with or somewhat paler than subdorsal area. Mid-ventral area dull grey suffused with colour of body. Spiracles with medium brown rims. Thoracic legs pale fawn.

Head width: 1.63 ± 0.06 mm (25 larvae).

Duration of stadium: 4.4 ± 1.0 days (21 larvae).

Fifth-Stadium Larva (Figs. 4, 6–9). Head light orange-brown with cherry-red reticulations and markings. Prothoracic shield fawn, usually heavily suffused with red or mauve, usually poorly distinguished from trunk. Suranal shield red or mauve, essentially indistinguishable from remainder of trunk. Mid-dorsal band varying from medium chocolate-brown to light red, often paler near posterior end of each segment so that it has a broken appearance. Subdorsal area varying from mauve to red, sometimes well-defined from mid-dorsal band, sometimes almost indistinguishably fused with it. Supraspiracular area darker than subdorsal area or concolorous with it; occasionally suffused with red or spotted with brown and often with white arcuate marks. Spiracular band light yellow or cream. Suprapodal area cherry-red or mauve,

paler than dorsal region, also with white arcuate marks. Mid-ventral area grey, sometimes suffused with pink. Spiracles with dark-brown rims. Thoracic legs pale fawn or cream.

Head width: 2.60 ± 0.10 mm (16 larvae).

Duration of feeding phase of fifth stadium: 5.3 ± 1.7 days (21 larvae).

Duration of prepupal phase of fifth stadium: 3.3 ± 1.0 days (12 larvae).

Pupa (Figs. 5, 10, 11). Orange-brown. Spiracles on a level with general surface of cuticle or borne in very shallow depressions. Rims of spiracles only weakly projecting. Anterior areas of abdominal segments 5, 6 and 7 conspicuously but rather finely pitted. Apex of proboscis terminating between apexes of forewings. Cremaster consisting of two elongate, slender, slightly curved spines borne at the apex of a rounded prolongation of tenth abdominal segment.

Length from anterior end to posterior margin of fourth abdominal segment: 11.1 ± 0.6 mm (17 pupae).

Acknowledgments

I am grateful to Mr. John E. H. Martin of this Institute for the fine photographs accompanying this paper and for his assistance in the field. I appreciate the help of my associate, Mr. E. W. Rockburne, who measured the immature stages and drew the cremaster area of the pupa.

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THE PAINTED LADY BUTTERFLY, *VANESSA KERSHAWI* (NYMPHALIDAE), OF AUSTRALIA AND NEW ZEALAND

Williams (1970, *J. Lepid. Soc.* 24: 157–175) refers to the Painted Lady Butterfly of Australia, New Zealand and some Pacific Islands as a form *kershawi* of *Vanessa cardui* (Linn.). He says that this form has slight differences in structure and wing markings, and has sometimes been considered as a distinct species.

I would like to point out that van Son (1966, *J. ent. Soc. Qd* 5: 66) has shown *Vanessa kershawi* (McCoy) to be a distinct species on the basis of genitalia. There are also constant differences in wing markings which support the separation of *kershawi* from *cardui*.

Recent migrations of *V. kershawi* in Australia have been recorded by Smithers and Peters (1966, *J. ent. Soc. Qd* 5: 67–69) and Smithers (1969, *Aust. Zool.* 15 (2): 188–194).

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BIOLOGICAL AND SYSTEMATIC CONSIDERATIONS ON THE "EMARGINANA GROUP" OF THE GENUS *EPINOTIA* (TORTRICIDAE)[1]

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In his revision of the Eucosminae, Heinrich (1923) considered the three Nearctic members of the genus *Epinotia* Hübner with an emarginate termen of the forewing to constitute a distinctive species group. In his treatment he gave only a few features required to separate the species, presented photographs of genitalia preparations which do not illustrate diagnostic features, and gave no biological information other than host records.

In this paper I will illustrate the male genitalia of these three species, and give additional distributional and biological information for the group based on material in the California Insect Survey, University of California, Berkeley, California. Discussions of the biological features of *E. emarginana* and *E. crenana* are based on notes taken by J. A. Powell and the author. In addition, a lectotype is selected for *Epinotia emarginana* (Walsingham).

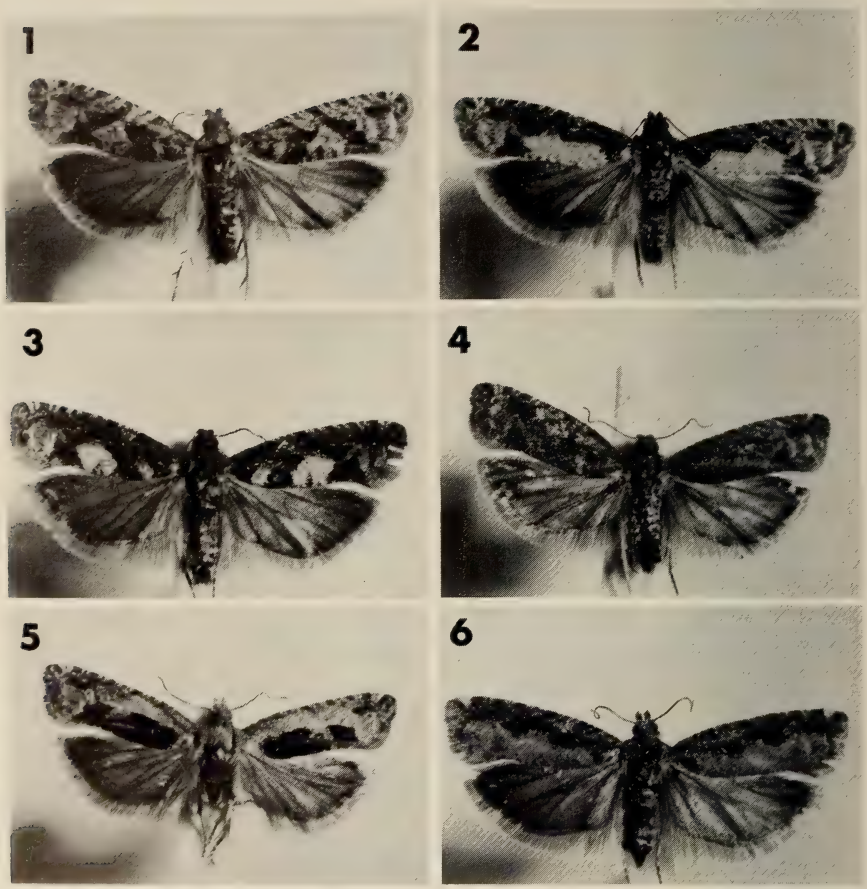
Epinotia emarginana (Walsingham)

Proteopteryx emarginana Walsingham, 1879, Illus., Lepid. Heter. Brit. Mus., 4:68.
Epinotia emarginana; Heinrich, 1923, U.S. Nat'l Mus. Bull. 123:218–219; MacKay, 1959, Can. Ent. Supp. 10:113; Powell, 1962, Pan-Pac. Entomol. 38:134; Powell, 1964, Univ. Calif. Publ. Entomol. 32:33, 51.

The late N. S. Obraztsov examined the type series of this species in the British Museum (Natural History), and selected a lectotype, but he did not publish this designation. In order to fix the specific identity of this species I designate the specimen indicated by Obraztsov to serve as the **lectotype** of this species. This individual is a male syntype and bears the following data: "above Potter's Valley, Mendocino Co., California 13. VI 1871 Wlsm slide 11604." A photograph of the genitalia of the lectotype is shown as Figure 7.

This "species" presents a number of perplexing problems. All of these relate to the possibility that two sibling species are included under the name *emarginana*. The information which indicates this possibility is biological and will be presented after a discussion of the morphological features of *emarginana*.

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Figs. 1–6. Examples of *Epinotia emarginana* polymorphs. 1, 2, Males, Strawberry Canyon, Alameda Co., Calif., 16 April 1960, r. f. *Quercus agrifolia* (J. Powell); 3, male, Applegate vic., Placer Co., Calif., 24 April 1961, r. f. *Quercus kelloggii* (J. Powell); 4, female, Orinda, 1 mile north, Contra Costa Co., Calif., 19 April 1967, r. f. *Quercus agrifolia* (P. Opler); 5, female, Fairfax, 2 miles south, Marin Co., Calif., 30 April 1967, r. f. *Quercus agrifolia* (P. Opler); 6, female, Applegate vic., Placer Co., Calif., 24 April 1961, r. f. *Quercus wislizenii* (J. Powell).

Morphologically this species differs from the other two members of the complex in maculation features, scaling of the labial palpi, and characteristics of the male genitalia.

The coloration of the legs, hind wings and abdomen is relatively invariable. The legs have the femur tan scaled. The pro- and mesothoracic tibiae are brown with a few tan scales intermixed, while the mesothoracic tibiae are pale tan. The tarsomeres are brown basally and edged with

pale tan distally. The hind wing is brown. The abdomen is brown dorsally and pale gray-tan ventrally.

While the above features are relatively constant, the coloration of the head, dorsal surface of the thorax, and particularly that of the forewings is extensively polymorphic. The color and pattern of these latter features appear to be determined by a number of independently operating genes or sets of genes. Thus there appears to be no definable set of polymorphs. In fact, it is almost impossible to find two individuals with nearly identical wing color and pattern. The ground color varies from tan, gray, various shades of brown, chestnut to black; the wing pattern may be obsolescent, with a large patch on the inner margin, several patches in the wing median, or a general mosaic of various colors. Several frequent morphs are shown in Figures 1–6. Throughout this melange of variation the pattern of the costal margin, apex, and outer margin tends to remain constant. The costal margin usually has seven white, cream, or silvery outwardly angled marks, each of which is divided by a small patch of dark scales. On the posterior half of the forewing just in from the outer margin are two parallel patches of scales which appear silvery in reflected light. The fringe on the outer margin is of white-tipped brown scales.

Because of the pattern of scaling, the labial palpi of *E. emarginana* are distinctively shaped when viewed laterally. The dorsal margin is convexly curved, the outer margin truncated, and the ventral margin straight (Fig. 13).

The male genitalia of *E. emarginana* are characterized by the absence of a gnathos, by the recurved arms of the socii, which are dentate dorsally, by the blunt uncus, by the neck incurvation (*sensu* Heinrich, 1923) at the ventral margin which extends half the width of the valva and by the rounded valval tips (Fig. 16).

The female genitalia are illustrated in Figure 19; the female genitalia of the other two species differ little from that of *E. emarginana* and are not illustrated.

Biological information suggests that two sibling species may be involved in populations presently referred to *emarginana*, although intensive morphological comparisons have not supported this thesis. Of the two putative entities one utilizes species of *Quercus* (Fagaceae) as hosts, while the other feeds on *Arctostaphylos* and *Arbutus* (Ericaceae).

The life cycles are similar for both host types, but apparently are temporally out of phase. Larvae are found on *Quercus* primarily during April but have been found as early as 16 March and as late as 10 May. During this time the larvae show a preference for the flowering parts, but will

also feed on young foliage. Larvae associated with *Arctostaphylos* were collected on young foliage between 19 May and 6 June. The larvae on *Arbutus* represent a single lot collected in flowers of *Arbutus menziesii* Pursh on 14 April.

Upon reaching maturity the larvae drop from the hosts and pupate. The cocoons are covered with detritus and soil particles. Eclosion occurs about three weeks later; moths originating from oak emerging during April and May, those from manzanita, during June.

The newly emerged adults are not functionally reproductive and possess an inordinate amount of fat body material. Adults collected in the fall still display this pre-reproductive condition. Beginning in January, six to eight months after eclosion, and continuing into April mated females may be found in the field. At this time males are rare, although the collection of a pair *in copula* on 6 March supports the thesis that mating does not occur until after winter has passed. Eggs are laid on twigs or leaves of the host. Females collected on 8 January and 6 February laid eggs while caged in the laboratory.

Presumably if two species are involved, differential timing of reproductive maturation, and mating could serve as an isolating mechanism. However, if mating and oviposition of a single species is occurring in a continuum, the early developing females presumably find *Quercus* to be preferrable oviposition substratum while late developing females find *Arctostaphylos* to be the suitable oviposition substratum.

The following constitute rearing records for this species based on material in the California Insect Survey. Data for adults reared from Fagaceae and Ericaeae are listed separately.

Records from Fagaceae. Alameda Co.: Berkeley, IV-14-58 r. f. *Q. agrifolia*, 1♀ emgd. V-5-58 (J. Lannon); Strawberry Cyn., IV-16-60, IV-6-67, IV-11-68 r. f. *Q. agrifolia* JAP 60D3, 67D15, 68D126, 49♂♂ 44♀♀ emgd. V-8/15-60, V-10-67, V-5/18-68 (J. Powell, P. Opler). Contra Costa Co.: Antioch, 2 mi. E., IV-8-67 r. f. *Q. agrifolia* JAP 67D61, 1♂ emgd. V-4-67 (P. Opler); Orinda, 1 mi. N., IV-19-67, IV-9-68 r. f. *Q. agrifolia*, *Q. kelloggii*, JAP 67D75, D 81, 68D87, 6♂♂ 4♀♀ emgd. V-15/16-67, V-5/14-68 (P. Opler); Russell Farm, 4 mi. NE Orinda, IV-7-67, IV-8-67 r. f. *Q. agrifolia* JAP 67D15, 68D105, 5♂♂ 4♀♀ emgd. V-12-67, V-3/12-68 (P. Opler); Walnut Creek, V-10-67 r. f. *Q. lobata* JAP 67E21, 1♀ emgd. V-30-67 (J. Powell). Fresno Co.: Kings Canyon Nat'l Prk., IV-16-60 r. f. oak in chapparal, 1♂ emgd. V-19-60 (W. E. Ferguson). Glenn Co.: Elk Crk., 10 mi. NW, IV-21-68 r. f. *Q. dumosa*, *Q. wislizenii* var. *frutescens* JAP 68D167-168, 2♂♂ 2♀♀ emgd. V-16/20-68 (P. Opler). Marin Co.: Fairfax, 2 mi. S, IV-29-67 r. f. *Q. agrifolia* JAP 67D134, 1♂ 1♀ emgd. V-29/VI-2-67 (P. Opler); Inverness, 2 mi. SE, IV-13-68 r. f. *Q. agrifolia* JAP 68D130, 1♂ 1♀ emgd. V-16/18-68 (P. Opler). Placer Co.: Applegate, vic., IV-24-61 r. f. *Q. kelloggii*, *Q. wislizenii* JAP 61D9, 2♂♂ 3♀♀ emgd. V-13/24-61 (J. Powell); Rocklin, IV-18-68 r. f. *Q. wislizenii* JAP 68D142, 3♂♂ 2♀♀ emgd. V-12/18-68 (P. Opler). San Francisco Co.: Golden Gate Park, IV-[illegible] r. f. *Q. agrifolia* JAP 66D15, 68D50, 2♂♂ emgd. V-15-66, V-18-

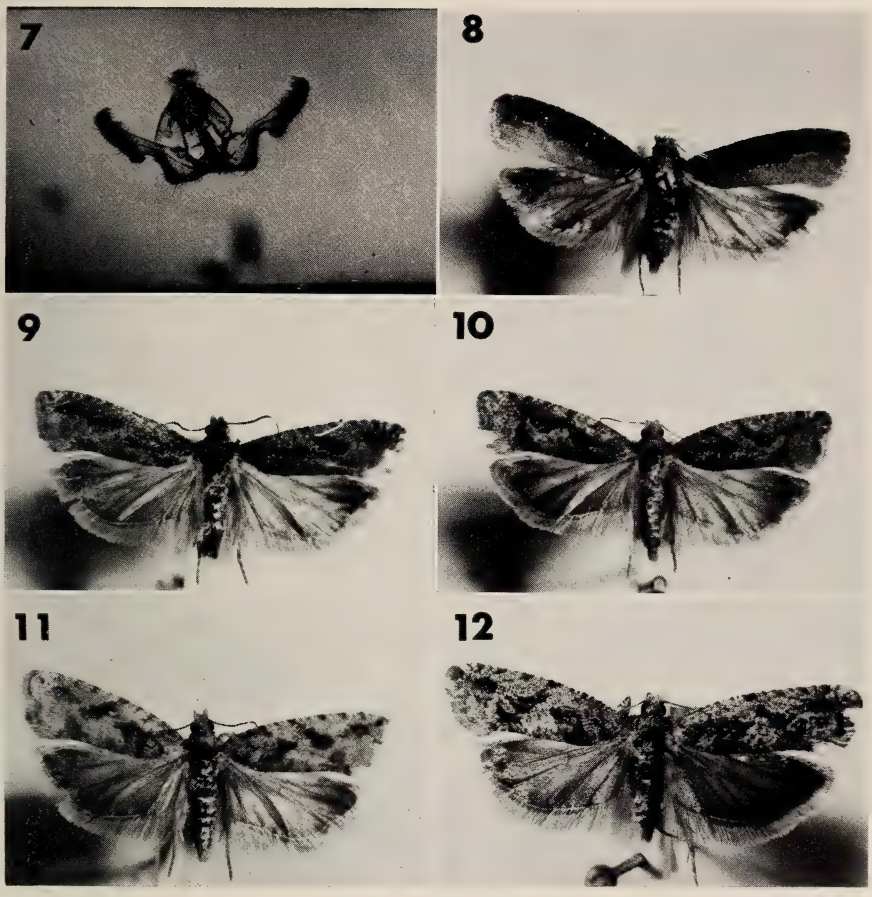


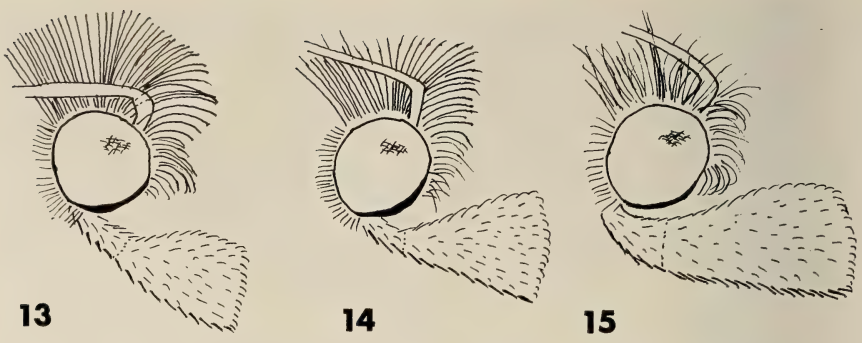
Fig. 7. Male genitalia from lectotype of *Proteopteryx emarginana* Wlsm.

Figs. 8–11. Polymorphs of *Epinotia crenana*. 8, Female, Berkeley Hills, 1400′, Contra Costa Co., Calif., 15 April 1968, r. f. *Salix* sp. (P. Opler); 9–11, male and two females, Pacific Grove, Monterey Co., Calif., 15 April 1962, r. f. ornamental *Salix* (J. A. Chemsak).

Fig. 12. *Epinotia cercocarpana*, female, Crook Creek lab., 10, 150′, White Mountains, Mono Co., Calif., 4 July 1961, r. f. *Cercocarpus ledifolius* (J. Powell).

68 (P. Opler). Santa Barbara Co.: Santa Cruz Isd., Prisoner's Harbor, III-16-69 r. f. *Q. agrifolia* JAP 68C52, 10♂♂ 9♀♀ emgd. IV-10/27-69 (P. Opler & J. Powell). Shasta Co.: O'Brien, Shasta Lk. Rec. Area, JAP 68D159, D161, 6♂♂ 5♀♀ emgd. V-16/23-68 (P. Opler); Project City, IV-20-68 r. f. *Q. douglasii*, *Q. lobata* JAP 68D162-3, 2♂♂ emgd. V-16-68 (P. Opler). Tehama Co.: Redding, 10 mi. E, IV-20-68 r. f. *Q. wislizenii* JAP 68D156, 1♂ emgd. V-18-68 (P. Opler).

Records from Ericaceae. Contra Costa Co.: Berkeley Hills, IV-14-66 r. f. *Arbutus menziesii* JAP 66D18 emgd. V-9-66 (J. Powell & J. Wolf). Marin Co.: Alpine Lake, VI-4-56, VI-6-57 r. f. *Arctostaphylos* sp. JAP 57F8 emgd. VI-27-56,



Figs. 13–15. Schematic view of heads of *Epinotia* spp. showing shape of labial palpi. 13, *E. emarginana*; 14, *E. crenana*; 15, *E. cercocarpana*.

VII-1-57 (J. Powell). Mendocino Co.: Booneville, vic., VI-1-57 r. f. *Arctostaphylos* JAP 57F1 emgd. VI-21/VII-1-57 (J. Powell); Leggett, V-19-66 r. f. *Arctostaphylos* JAP 66E17, emgd. VI-14/23-66 (J. Powell & J. Wolf).

Epinotia crenana (Hübner)

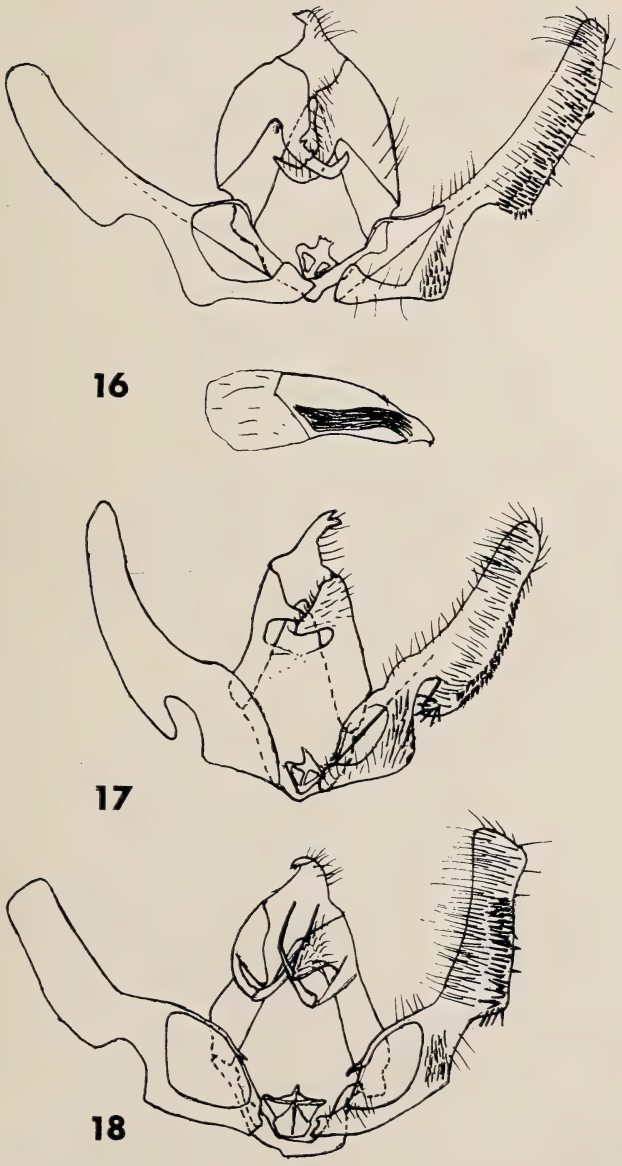
Tortrix crenana Hübner, 1827, Samm. Eur. Schmett. Tort. Fig. 242.
Epiblema crenana; Staudinger and Rebel, 1901, Cat. Lepid. 2, #2133.
Eucosma crenana; Dyar, 1904, Proc. Ent. Soc. Wash. 6:117.
Proteopteryx columbia Kearfott, 1904, Can. Ent. 36:112.
Proteopteryx columbia mediostriana Kearfott, 1904, Can. Ent. 36:114.
Epinotia crenana; Heinrich, 1923, U.S. Nat'l Mus. Bull. 123:219; MacKay, 1959, Can. Ent. Supp. 10:110; Powell, 1962, Pan-Pac. Entomol. 38:134.

This Holarctic species possesses a range of polymorphism less extensive than that displayed by *E. emarginana*. *E. crenana* lacks the distinct costal marks and reflective patches of *E. emarginana*. Dull browns and tans are the colors most often shown by the various morphs, while white and reddish are generally lacking. One macular feature which is frequently present in *crenana*, but lacking in the other two species, is a thin black streak on the costal half of the forewing two-thirds of the distance from the base. Some typical morphs of *crenana* are shown in Figures 8–11.

The labial palpi of *E. crenana* when viewed laterally have the dorsal and ventral margins flaring and truncated distally (Fig. 14).

Genitalically this species is quite distinct (Fig. 17). In addition to the invasion of the cucullus by the neck incurvation mentioned by Heinrich (1923, p. 198), the uncus is notched with two acuminate projections distally, the socii are triangulate and the gnathos is strongly reduced.

The larvae of *crenana* feed exclusively on *Salix* species (Salicaceae). The larvae are found in shelters on young foliage or as inquilines in the



Figs. 16–18. Male genitalia of *Epinotia* spp. 16, *E. emarginana.* (PAO prep. 115); 17, *E. crenana.* (JAP prep. 49); 18, *E. cercocarpana.* (JAP prep. 2463).



Fig. 19. Female genitalia of *Epinotia emarginana*. (PAO prep. 65).

leaf and petiole galls of tenthredinids. Larval collection dates, which range from 8 March to 17 September, indicate that *crenana* is multiple-brooded.

Distribution. Holarctic; British Columbia and Manitoba constituted the known distribution in North America at the time of Heinrich's revision (1923). The California Insect Survey has reared material from several localities in California and Nevada as follows: **California.**—Alameda Co.: Berkeley, Univ. Calif. Campus, III-11-58 r. f. *Salix* JAP 58C7 emgd. IV-8-58 (J. Powell). Contra Costa Co.: Berkeley Hills, 1400′, NE Oakland, IV-15-68 r. f. *Salix* sp. JAP 68D137 emgd. V-18/23-68 (P. Opler); El Sobrante, III-8, IV-26-58 r. f. *Salix* JAP 58C2, D13, emgd. V-8/26, V-26/VI-9-58 (J. Powell). Monterey Co.: Pacific Grove, IV-15-62 r. f. ornamental *Salix* JAP 62D9 emgd. by V-22-62 (J. A. Chemsak). Los Angeles Co.: Pacific Palisades, V-56 r. f. *Salix* leaf galls (W. Hovanitz). Santa Clara Co.: San Jose, IV-16-61 r. f. *Salix lasiolepis* leaf gall emgd. VI-25-61 (L. R. O'Brien). **Nevada.**—Washoe Co.: 2 mi. SW Reno Hot Spg., 6100′, IX-17-65 r. f. *Euura* petiole gall on *Salix lasiandra* emgd. X-28-65 (E. L. Smith).

Epinotia cercocarpana (Dyar)

Eucosma cercocarpana Dyar, 1903. Proc. Ent. Soc. Wash. 5:297.
Epinotia cercocarpana; Heinrich. 1923. U.S. Nat'l Mus. Bull. 123:219.

E. cercocarpana is characterized by its nonpolymorphic, mottled with black gray appearance (Fig. 12). The vestiture of the head, thorax and forewing is composed of white, black, and white-tipped black scales.

The forewing maculation is somewhat variable, but cannot be termed polymorphic. There is usually a small white triangular patch on the costal margin at the apex, a triangular black or dark gray patch on the inner margin near its junction with the outer margin, and an outwardly directed black bar beginning on the costal margin halfway from the base and extending nearly to the triangular black patch. In five of seven specimens the scaling of the thoracic tergites is black on the posterior half and gray on the anterior half.

In lateral view the labial palpi appear to be convexly curved dorsally and slightly flaring ventrally due to the pattern of scaling (Fig. 15).

In addition to triangular socii mentioned by Heinrich (1923, p. 198), there are several other distinctive features in the male genitalia of the moth (Fig. 18). The gnathos arms are separate, narrow, and strongly recurved, the neck incurvation of the valva is the shallowest of any of the species in this group and the valvae are truncate distally.

Distribution. The species was previously known only from the type of locality, Platt Cyn., Douglas Co., Colorado. New distributional data are as follows: **Arizona.**—Mojave Co.: Hualpai Mtn. Park, VI-2-68, at B/W light (P. Opler & J. Powell). **California.**—Inyo Co.: Crooked Crk. Lab., 10,150′, White Mtns. VII-4-61 r. f. *Cercocarpus ledifolius* JAP 61G1.1 emgd. VIII-31-61 (J. Powell). Tuolumne Co.: Strawberry, VIII-20-60 (D. Q. Cavagnaro). **Colorado.**—El Paso Co.: Rock Crk. Cyn., Colorado Springs VII-16-59, VII-15-60 (Margot May). Jefferson Co.: Golden, X-25-67 (no collector, Bryant Mather Collection).

Acknowledgments

I wish to thank F. H. Rindge, American Museum of Natural History, New York, for loaning the photographs of type material for *Epinotia emarginana* made by the late N. S. Obraztsov.

J. A. Powell and G. R. Rotramel, University of California, Berkeley, provided early insight into the present complex and reviewed the manuscript of this paper.

My wife, Sandra, gave welcome secretarial assistance.

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A MIGRATION OF *KRICOGONIA CASTALIA* (PIERIDAE) IN NORTHERN MEXICO[1]

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Kricogonia castalia Fabricius ranges from northern South America (Venezuela) through Central America and Mexico into Texas and through the Caribbean region (Haiti, Puerto Rico, Jamaica) occasionally to southern Florida. It has been reported (often under the synonymous name, *K. lyside* Latreille) as common in Texas, and stray individuals have been recorded as far north as Colorado, Nebraska and Illinois (Ehrlich and Ehrlich, 1961). According to Godman and Salvin (1887–1901, p. 150), *K. castalia* (as *K. lyside*) "does not appear to be a very common insect" in Mexico and Central America.

A migratory flight of this species, observed in central Tamaulipas on 11 July 1961, suggests it sometimes becomes at least locally abundant in northern Mexico. The butterflies were seen moving generally from northwest to southeast, toward the Gulf of Mexico. These observations were made about 80 miles inland from the Gulf, along Highway 101, commencing about 14 miles northeast of Ciudad Victoria near Güémes. From there, the width of the stream of *Kricogonia* was measured as 53.5 miles on to the northeast. I have no estimate of the length of the emigrating stream. Since the terrain along this part of the highway is rather flat with only light and scattered vegetation, the butterflies, especially when moving in dense groups, could be seen several hundred yards to either side of the road. Their bright yellow on pale yellow color also made them easy to see from afar.

Density of the migration varied within the broad zone described, yet for the entire 53.5 miles some butterflies were always in sight, moving generally toward the southeast. The widest of the dense streams within the migration was 9.5 miles across. Since the butterflies flew generally within six feet of the ground, and mostly about two or three feet above the surface, large numbers of them were struck and killed by our vehicles as we drove across the emigrating stream at about 50 miles per hour. It is not easy to estimate the density of insects in such an emigration, but my counts made at the time suggest about 1100 butterflies per minute were crossing an average mile of front along the highway (or perhaps some 55,000 per minute were passing a line at right angles to the direc-

[1] Contribution no. 1462 from the Department of Entomology, University of Kansas, Lawrence.
[illegible] thank Dr. Orley R. Taylor for reading the original manuscript of this note and making [illegible] particularly concerning dissection of females.

tion of the stream). A sample of 18 specimens was easily taken in a couple of minutes.

At the time of these observations, the weather was hot and the sky was partly cloudy, the gathering clouds producing a light sprinkle of rain approximately 65 miles northeast of Ciudad Victoria, near mid-afternoon, just before we drove out of the migration. There was a light to moderate breeze from east-northeast, so that the butterflies, on a northwest to southeast course, were moving slightly into the wind.

In the sample collected, there was a 3.5 to 1 ratio of females to males (14♀, 4♂). Three females with large abdomens were dissected, and it was found that none contained any eggs whatsoever (yet large amounts of what appeared to be fat) and that each contained the hardened remains of one large spermatophore. In the males, there was noticeable variation in the extent of the black spot near the costal margin of the hind wing. Adults of *K. castalia* have been seen feeding on blossoms of mesquite, and Klots (1951) reports lignum vitae (*Guaiacum officinale*) as larval food for this species in Puerto Rico. Unless this emigration had come a long way, it seems the food plant must have been some common member of the semi-desert flora.

Migrations of pierid butterflies are frequently observed and reported in the entomological literature; however, as far as I can determine, this is the first record of a migration of a species of *Kricogonia* (there are only two species in the genus). Recent books on insect migration (Williams, 1958; Johnson, 1969) do not mention the genus.

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OBSERVATIONS ON *PAPILIO ARISTODEMUS PONCEANUS* (PAPILIONIDAE)

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Papilio aristodemus ponceanus Schaus is a swallowtail which few Lepidopterists have seen alive. As the North American population of a polytypic Antillean species, it is limited to tropical hardwood hammocks in southern Florida. Before the extensive land clearing which accompanied settlement, its range may have extended from a southwestern limit near Marathon in the Florida Keys, into peninsular Florida as far north of Miami as soil character and climatic fluctuations would permit these hammocks to flourish. Today its range is greatly reduced.

The life history was described by Grimshawe (1940) who also illustrated some of the early stages. The accompanying figures will supplement her photographs.

During late spring of 1970, I made observations which can be added to those of Grimshawe. I spent the first week of June in the habitat of *P. a. ponceanus* at times of day varying from dawn to just before sunset. During this time I watched about 35 *ponceanus.* Nearly half of these were caught in order to determine sex and condition, but almost all were set free. Except for a female released and then recaptured an hour later and a mile away, it is not possible to say how many individuals these sightings might represent.

Circumstances did not permit the rigorous survey with marked specimens and large sampling which would have made these notes more objective. Nevertheless I offer this tentative account because *ponceanus* is on the verge of extinction. Collectors hunt it down while developers are destroying its habitat (Kimball 1965, Klots 1951). As I hope to show, over-protective conservation practices can endanger it further.

Published dates for *ponceanus* (Henderson 1945a, 1945b, 1946) extend mostly from April to June. Although the finding of two larvae in their third instar on June 5 (discussed below) indicates that parents had been on the wing in mid-May, the main 1970 flight seemed to have started with the heavy rains which culminated in Hurricane Alma near the end of May. Local newspapers claimed that this had been the wettest May in years. And when I arrived on the afternoon of June 2, residents told me about the unusually heavy and continuous rains which had stopped just the night before. The weather stayed mostly fair until the 5th, when it rained heavily late in the afternoon and intermittently through the

night. Between these two rains *ponceanus* was locally in fresh condition and not rare, whereas the usually common butterflies were scarce and worn. After the rain on the 5th, the few *ponceanus* I could find were all shabby, and ordinarily abundant species such as *Nathalis iole* Boisduval, *Junonia coenia* (Hübner) and *Danaus gilippus berenice* (Cramer) first appeared as freshly-emerged singletons.

Adults. *Ponceanus* usually flew in brushy hammocks. The earliest any were seen was just before 9 AM (Eastern Daylight Time) on two bright days, in each instance a female visiting the blossoms of Cheese Shrub (*Morinda Roioc* L.) at the eastern edges of hammocks. The latest observation was at 5 PM, a freshly-emerged female hovering low over Cheese Shrub blossoms at the sunlit west edge of open hammock. On June 2, 1970, sunrise in the Miami area was at 6:29 AM (E.D.T.) and sunset was at 8:08 PM.

Before the hottest part of the day, which was from 1 to 2 PM, both sexes were within the hammocks, fluttering in diffused light about a foot above the ground at blossoms of Guava (*Psidium guajava* Raddi). Guava was abundant within the hammocks whereas Cheese Shrub grew commonly at the edges of hammocks or out in the open. Those *ponceanus* seen at flowers within hammocks were invariably visiting Guava, while at the edges of hammocks or out in the open they were visiting only Cheese Shrub when they were on flowers at all.

On bright days the butterflies flew higher during the hot afternoon. Males patrolled the tree tops at a height of 10 feet or more, sometimes descending into open spaces to investigate any other *ponceanus*. However, no combats were observed nor was it possible to see whether individual males kept to flyways above the forest canopy. During the heat of the day I rarely saw a male descend from the canopy to feed at flowers.

At 10 o'clock on a hazy morning after a drizzle, I found a male of *Papilio cresphontes cresphontes* Cramer and a male *ponceanus* along an open trail. After a short encounter the *ponceanus* veered into the woods while the *cresphontes* settled on a shrub to bask. Three other *cresphontes* were found in open places near midday; all were males visiting various flowers in bright sunlight.

Regardless of how fresh they were otherwise, many *ponceanus* males had one or both hind wings torn more or less cleanly at a 90° angle to the anal margin, often with the tails intact. No females were found damaged in this way. Such mutilation may be evidence of bird attack, although no specimen bore a v-shaped beak mark. Although none of the four male *cresphontes* had torn wings, one was missing a tail which apparently had

been pulled out from its root. The tails of *cresphontes* are spatulate, marked above and below with a conspicuous yellow spot; *ponceanus* tails are slender and dark. It is possible that the conspicuous *cresphontes* tails might offer marginal survival advantage by distracting the attention of birds from the body of the insect or from graspable parts of the wings. Male *ponceanus* seemed to fly just as strongly as male *cresphontes* when out in the open. I could not distinguish the two species by flight alone.

A *ponceanus* male and a *cresphontes* male of about the same size were roughly compared for wing strength by measuring the diameter of each wing vein with a micrometer at a point ¼" from the outer margin. The averages were then taken. The average reading for the *ponceanus* male was .0165" while the *cresphontes* average was only .0150". A female of each species similarly compared showed less discrepancy. They both averaged .0185". Though the *ponceanus* male might seem to be the more robust insect, other things being equal, it is worth mention that the pointed shape of *cresphontes* wings increases the rigidity of wing surface relative to vein diameter. From the standpoint of total mass that must be kept in motion to maintain a given speed, to say nothing of maneuverability, the pointed *cresphontes* wings seem to be more efficient than the blunt *ponceanus* wings.

In an attempt to see how important wing pattern or color might be in species recognition, I looked at a pair of *cresphontes* and a pair of *ponceanus* under long-wave ultraviolet light. The bulb used was a General Electric 8 watt BLB, which I hoped would approximate the wavelength by which these insects perceive pattern or color. Under ultraviolet illumination the relation of light spots to dark background on the upperside of both species was similar to the relation visible in daylight. The undersides of the *cresphontes* pair also looked much as they do in daylight. However, the undersides of the *ponceanus* pair differed strikingly from *cresphontes*. The wide orange-brown band on the hind wings which is so characteristic of *ponceanus* (but which tends to vanish in Antillean *aristodemus* populations) was invisible under ultraviolet light. Furthermore, the yellow underside ground color was nearly obliterated. Except for the blue lunules on the hind wings, the entire underside of the *ponceanus* pair appeared a deep violet brown. For this reason I suspect that *cresphontes* and *ponceanus* can distinguish each other in flight better than a Lepidopterist can.

Living males of *ponceanus* smell strongly of sweet lemon with a suggestion of vanilla, while a freshly-emerged female had no perceptible scent. A living male *cresphontes* caught in the same place at the same

time, had a faint odor which is best described as acrid. These scents fade soon after death.

At 10:15 AM in a dimly-lit trail through brushy hammock I saw a female and two male *ponceanus* visiting flowers at opposite ends of a Guava tangle. The fresher of the two males eventually approached this slightly worn female while she was still feeding. He hovered over her. She then settled on the ground with wings flattened and vibrating, raising her abdomen. The male fluttered on the ground behind and then rose over her before flying away. In contrast, during part of a *cresphontes* courtship witnessed at 3 PM on a bright day in May 1966, the pair flew straight up until they were hovering about 30 feet above nearly bare ground. Their nuptial flight was interrupted by a bird which darted up out of nearby mangroves to attack one of the butterflies from a "five o'clock" position. The *cresphontes* evaded this attack by an easy dip sideways while its would-be mate fled.

Female *ponceanus* behaved differently from males. The few times they were seen along the edges of hammocks their sex could seldom be determined unless they were captured. But when flying within hammocks in search of Torchwood, *Amyris elemifera* L., the larval foodplant, they fluttered slowly about 6 feet from the ground, with the axis of the body at about 45° from horizontal.

Oviposition. Several *ponceanus* females at the outer edges of hammocks were seen to investigate shrubs of Wild Lime, *Zanthoxylum Fagara* (L.), a common larval foodplant of *cresphontes* in southern Florida. These females all flew lower than usual, at about 4 feet. One female (12:30 PM) flew 12 feet out of her straight course to pass near one of these shrubs. Two others were seen hovering around Wild Lime at 12:45 PM and 1 PM. Since Wild Lime flowers are small and inconspicuously located in the axils, I assumed that the *ponceanus* females were seeking nectar. But none of these shrubs proved to be in bloom.

On June 5 at 1 PM I followed a female as she fluttered through an overgrown trail in a way that I had learned to associate with oviposition. With wings vibrating closely together over her back, she perched for an instant on a young shoot of Wild Lime at a height of 6 feet and laid an egg on the leaf tip. I took this egg home to New York with me. The larva which it produced is illustrated in the figures. It is also the basis of some of the observations recounted below.

As will be apparent, this unexpected use of Wild Lime as a larval foodplant offers a clue to the way in which *ponceanus* is adapted to its habitat. Both Torchwood (the previously-recorded larval foodplant) and Wild Lime are pioneering shrubs in whose shade sprout other hard-

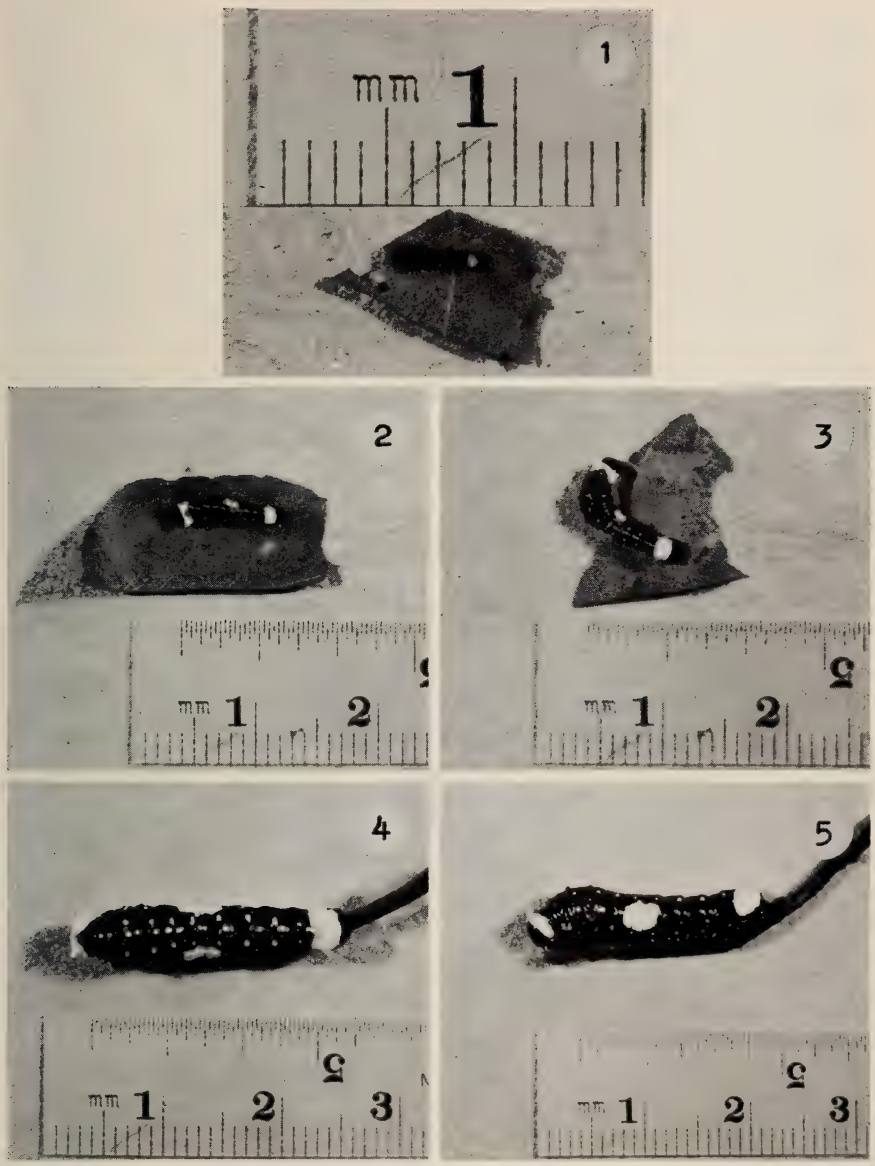
wood seedlings which can eventually grow up to hammock. Therefore both grow abundantly at the edges of advancing hammocks but are scarcer within the hammock itself, where they must struggle for light. Wild Lime seems to need more sunlight than Torchwood. It often grows completely exposed among low herbs, and conversely it is scarce in even fairly open hammock. At the borders of hammocks both plants are usually densely-foliated shrubs up to 8 feet tall, but inside hammocks they are slender trees over 15 feet tall, with fewer leaves. Presumably this change to an arboreal habit is partly an adaptation to keep them from having to struggle against their own shade in addition to the shade of overtopping vegetation.

Most of the Torchwood and Wild Lime and the *ponceanus* associated with them occurred in moderately shady hammock on rather bare limestone pitted with sinkholes. Torchwood but not Wild Lime was nearly as abundant in a still shadier habitat, proliferating on rich humus, but only one *ponceanus* was seen there. This was a female found at 12:30 PM flying higher than usual at about 15 feet within diffused sunlight just below the forest canopy. In the shadiest place of all, a dense mature hammock into which little light penetrated, no Torchwood and no *ponceanus* were seen.

In contrast to the preference for partial shade shown by female *ponceanus*, three female *cresphontes* were seen laying eggs on Wild Lime growing on a similar limestone formation (11 AM in October, 1968). Each *cresphontes* was completely exposed in bright sunlight, ovipositing at a height of about 5 feet.

Eggs and Larvae. After learning to recognize *ponceanus* females in search of the larval foodplants I was able to find eggs and larvae. It 11 AM on June 5, I followed a female to a spindly Torchwood tree growing in the shade. She laid an egg on one of its new leaves. There were two other eggs and eight larvae in various stages of development, even two larvae in their third instar, on this one tree. On Torchwood trees in similar situations I found other eggs and larvae but fewer of them. Eggs were always on top of young leaves (but not always the youngest leaves) and once on the rachis. Larvae were invariably on top of the youngest and tenderest leaves, the new growth brought out by the spring rains. Even the two third-instar larvae were feeding on young shoots and refused older growth when it was offered.

No larvae were found on the few Wild Lime trees within the hammock, nor on the numerous Torchwood and Wild Lime shrubs exposed to direct sunlight along the edges of hammocks. Three *Papilio* eggs were found in sunlight at a height of 3 feet on a Torchwood shrub growing half ex-



Figs. 1–5. *Papilio aristodemus ponceanus* Schaus. 1, First-instar larva, dorsal aspect; 2, second-instar larva, dorsal aspect; 3, third-instar larva, dorsal aspect; 4, fourth-instar larva, dorsal aspect; 5, fourth-instar larva, lateral aspect.



Figs. 6–9. *Papilio aristodemus ponceanus* Schaus. 6, Fifth-instar larva, dorsal aspect; 7, fifth-instar larva, lateral aspect; 8, pupa, dorsal aspect; 9, pupa, lateral aspect.

posed along a trail. They did not produce detectable embryos. No *ponceanus* eggs or larvae were found lower than 3 feet or higher than 7 feet from the ground.

First- and third-instar larvae which had been feeding on Torchwood unhesitatingly accepted the youngest leaves of Wild Lime, and so did my newly-hatched larva which had not yet eaten. This larva was later transferred to potted Torchwood which I had brought back to New York with it. When the larva was in its second instar I ran out of young Torchwood shoots and had to give it slightly older leaves. It refused them. Thinking that perhaps the waxy integument of an older leaf made it too tough for food, I scraped the leaf edges with a razor blade, but the larva still would not eat. Finally I gave this larva young shoots of Prickly Ash, *Zanthoxylum americanum* Mill. from New Jersey. Prickly Ash, the preferred larval foodplant of *cresphontes* in the Northeast, grows in rocky places (limestone ledges in New Jersey, sandstone outcroppings in Illinois) much as the related *ponceanus* hostplants occur on well-drained limestone in Florida.

Prickly Ash lacks the waxy covering of its subtropical relatives. Even its mature leaves are tender. However, its youngest leaves are thick and hairy, unlike the young shoots of Torchwood and Wild Lime. The hungry *ponceanus* larva nibbled at the youngest growth of Prickly Ash but seemed to have trouble eating the thick edges of these leaves despite their tenderness. It reluctantly accepted leaves of intermediate age but fed so seldom that its second instar lasted 7 days instead of 5. As the larva matured it ate any Prickly Ash leaves offered, without apparent preference for younger ones. It was reared to the pupal stage on this substitute foodplant.

When kept at 80° F., about 5° lower than the average daytime temperature of its natural habitat, the *ponceanus* larva was remarkably irritable. Confined in a vial, it would jerk its head backward if the vial was jarred even slightly. If the vial was picked up, the larva shook its head from side to side. Though newly-hatched wild larvae and my own reared larva would protrude their white osmateria (producing an unpleasant smell) when I even touched the leaves on which they rested, my larva as it matured into its fourth and fifth instars became reluctant to do so even when prodded. At the same time it gradually abandoned its habit of resting on top of leaves. Instead it clung to twigs below the leaves when it was not actually feeding. Nearly mature *cresphontes* larvae found on Prickly Ash in northern Illinois, rested in a similar position.

Grimshawe noted the curious thirst of *ponceanus* larvae in all instars.

In Florida, when I temporarily confined young wild larvae at 85° F. with nearly saturated humidity, I never saw them drink. And when I reared my larva in New York under similar conditions it apparently did not drink during its earlier instars. But when in its fifth instar it was transferred to a roomy plastic box and kept at 80° F. with relative humidity which varied from 60% to 70%, it would seek out and quickly drink water droplets which I had scattered to keep the foodplant fresh.

Summary and Discussion

Papilio aristodemus ponceanus is found most often in old disturbed places which are growing up to hammock. Feeding of larvae and adults, courtship and oviposition occur in these second-growth hammocks, indicating that *ponceanus* is a forest insect. The sympatric *P. cresphontes cresphontes* feeds and reproduces in open places.

Ponceanus seems highly sensitive to moisture. It may emerge in numbers only after heavy or prolonged rains have ended the dry season and brought out new growth on its host plants. A twenty-year summary of South Florida weather records (Butson 1962) showed little change in relative humidity between dry and rainy seasons. In the shelter of hammocks, where there is usually no noticeable wind, the relative humidity would be even more stable. However, Butson pointed out that the first month of a rainy season usually has double the rainfall of the preceding dry month. The beginning of the rainy season in South Florida varies from late April to late June, the same months as the flight period of *ponceanus*.

The ability of pupae to remain dormant for longer than a year as noted by Grimshawe, may be a mechanism to synchronize adult emergence with the beginning of the rainy season which in turn produces abundant new growth for the larvae. In an exceptionally dry spring, emergence could be delayed or suppressed. It is possible that pupae respond to light intensity as well, for *ponceanus* does not emerge throughout the rainy season as Antillean *aristodemus* populations apparently do.

The habitat of *ponceanus* is more or less continuous except where man has destroyed it. But feeding adults disperse widely. Their distribution seems related to the freshness of Guava blossoms, the preferred adult foodplant within hammocks at the time of my observations. Adults would not be found at the same Guava patches for more than a day. However, one patch of Cheese Shrub blooming in the open attracted a male a day for three days. The short duration of Guava blossoms may aid the reproductive dispersal of *ponceanus*.

In contrast with the fluid distribution of feeding adults, the eggs and

larvae were distributed very narrowly. The single Torchwood tree which yielded eight larvae in various stages of development seems to indicate that it or its situation was especially attractive to several ovipositing females. This contention seems supported by the fact that other Torchwood trees of the same size growing in similar conditions, generally had larvae on them.

Young larvae will accept other foodplants rather than eat any but the tenderest leaves of the "right" foodplant. They will feed on at least two other Rutaceous plants besides Torchwood, the primary hostplant. Oviposition on one of these, Wild Lime, occurs in nature. Of course ready acceptance of Wild Lime does not necessarily mean that most larvae will thrive on this diet and mature into adults capable of reproducing. Nevertheless, the assured behavior of the female which oviposited on a Wild Lime tree growing in the shade, as compared with the hesitation of the three females seen around Wild Lime shrubs growing in the open, suggests that specific habitat might be a stronger stimulus to oviposition than specific foodplant. The fact that *ponceanus* females are only stragglers in open places and that Wild Lime is only a straggler in shady places makes it unlikely that oviposition on this secondary hostplant is frequent.

It is remarkable that the shady habitat of *ponceanus* is not the most favorable place for its primary hostplant either. As the price of reproductive isolation *ponceanus* lives out of step with both Wild Lime and Torchwood. Both are constantly being shaded out of hammocks, each at its own rate, by normal plant succession.

The mechanisms which maintain environmental separation between *ponceanus* and *cresphontes* are not fully understood. An initial hurdle of reproductive isolation may be environmental separation of virgin females which are feeding. Fertilized female *ponceanus* may have a genetically controlled preference for partial shade when ovipositing. As for males, there seems to be a tension zone at the edges of hammocks, characterized by occasional combat between cruising males of *ponceanus* and *cresphontes.*

In the mottled light of its habitat *ponceanus* may benefit from a pattern resemblance to *Heliconius charithonius tuckeri* Comstock & Brown. I was sometimes unsure whether a yellow-streaked butterfly vanishing into the edge of a hammock was a rare swallowtail or merely a common heliconian. When I saw such a butterfly from behind, foreshortening increased the resemblance.

It is well known that the wing patterns of *H. c. tuckeri* and *P. cresphontes* are "hard edged" while that of *P. a. ponceanus* is suffused. Pattern suffusion is a reputed characteristic of tropical mimetic butterflies

(Corbet & Pendlebury 1956), perhaps indicating that the need for close resemblance to a model is reduced by the preference for shady habitats which such mimics often show. I have already mentioned the "agreeable" scent of *ponceanus* males and the "disagreeable" scent of a male *cresphontes* from the same place. Further investigation could determine whether it is more than coincidence that some *cresphontes* hostplants belonging to the genera *Ruta*, *Dictamnus* and *Ptelea* have been responsible for photosensitive dermatitis in mammals (Muenscher 1951). My few dried Torchwood specimens have more and larger resin dots on young leaves from a completely exposed plant than on young leaves from a plant which grew in partial shade. It is conceivable not only that South Florida *cresphontes* might be protected by an irritant substance in some native *Rutaceae*, but also that shade-grown Torchwood and Wild Lime might be deficient in that irritant.

Putting conjecture aside, there is reason to believe that *Papilio aristodemus ponceanus* must continuously colonize new places partially deforested by storm or fire, which temporarily are in a state of regrowth suited to its habits. The extremes of heedless real-estate development and over-protective maintenance of mature hammocks both threaten to disrupt the natural cycle of renewal on which its survival depends.

Acknowledgments

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NOTES ON SOME SOUTH FLORIDA LEPIDOPTERA

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The following observations from the Florida Keys are additions to information published by Kimball (1965). These observations may be of interest because they represent apparently new records of habits, larval foodplant or extension of known range. Nomenclature and checklist numbers follow dos Passos (1964) for butterflies and McDunnough (1938) for moths. Plant names are taken mostly from Small (1933). I am indebted to Mr. George Avery of the Fairchild Tropical Gardens in Miami, Florida, who helped me in various ways and was also kind enough to identify two of the more difficult plants.

29. *Lerodea eufala* (Edwards). Extension of range. A few of these skippers were taken in December on Big Pine Key, visiting blossoms of *Croton linearis* Jacq. in the shadier parts of pine woods.

281. *Ascia monuste phileta* (Fabricius). During a migration of this species on Key Largo in June, a pair was found *in copula* within shady hammock at 1:15 PM on a sunny day, the dark female flying.

340. *Lephelisca virginiensis* (Guérin-Méneville). Extension of range. A colony was found in August on Big Pine Key, in rocky pinelands immediately adjacent to marshes.

380. *Strymon martialis* (Herrich-Schäffer). This very local species seems to prefer the blossoms of Bay Cedar (*Suriana maritima* L.) when available, to the flowers which it usually visits at other times.

451a. *Hemiargus ammon bethunebakeri* Comstock & Huntington. New larval foodplant. At 10 AM in early June a female laid an egg just above a lateral bud on Snowberry, *Chiococca alba* (L.) Hitchc., growing along a shady trail on Key Largo.

486c. *Anaea aidea floridalis* Johnson & Comstock. A butterfly trapped in a spider web was tasted and immediately discarded by the spider.

524b. *Metamorpha stelenes biplagiata* (Frühstorfer). Extension of range. In late October a colony was found on Big Pine Key, associated with *Blechum pyramidatum* (Lam.) Urban, which is probably the larval foodplant. The butterflies are very fond of the blossoms of Wild Lantana, *Lantana involucrata* L. When at rest with wings closed, they are hard to tell from the curled and blotchy leaves of Jamaica Dogwood, *Ichthyomenthia piscipula* (L.), which start to turn brown and fall at this time of year. One female apparently had been attracted to light, for early on

a rainy morning she was found among moths in the grass at the base of a streetlamp.

531. *Junonia coenia* (Hübner). This species and *Junonia evarete zonalis* Felder & Felder interbreed on Big Pine Key. *J. e. zonalis* is common along mudflats while *J. coenia* seems to prefer damp places on higher ground. The roads and fire lanes which have been opened on Big Pine Key may help to break down reproductive isolation of these two populations. Copulating pairs representing various intergradations were taken around 5 PM in December, when the sun was quite low. The fact that mating took place late in the day when light had shifted from the violet to the red end of the spectrum might have minimized any importance that pattern or color differences could have in courtship. If this interbreeding really represents secondary intergradation, it is to be expected that the two populations might formerly have diverged even less in courtship ritual than in appearance. The instance of abortive courtship listed below under *Euptoieta* suggests that in bright sunlight any rusty orange butterfly resting on the ground in a likely habitat might momentarily arouse the interest of a male *J. e. zonalis.*

624. *Euptoieta claudia* (Cramer). Extension of range. Occasional but fresh specimens were taken on Big Pine Key in May, August and October. They were found in both very wet and very dry habitats. One female briefly responded (spreading out of wings and raising of abdomen) to a hovering *Junonia evarete zonalis.*

628d. *Dryas julia cillene* (Cramer). Extension of range. A battered female was taken in August on Big Pine Key along the edge of dry hammock on an outcropping of Key Largo Limestone.

818d. *Automeris io lilith* Stkr. New larval foodplant. Larvae were found on *Croton linearis* on Big Pine Key in December.

860a. *Eacles imperialis didyma* Beauv. Extension of range. A badly smashed specimen was found among other moths at the base of a streetlamp on Big Pine Key in October.

870. *Lymire edwardsii* Grt. Numerous cocoons were found at the base of a Sapodilla, *Sapota Achras* Mill., trunk on Big Pine Key in August.

1954. *Xanthopastis timais* Cram. Third and fourth instar larvae found skeletonizing the leaves of *Hymenocallis keyensis* Small on Big Pine Key in October, freely accepted Iceberg Lettuce as a substitute foodplant in New York and were reared to maturity on it.

3816a. *Composia fidelissima vagrans* Bates. One of these moths was removed unharmed from a spider web on Big Pine Key in December. Unlike netted specimens, it responded to being handled by squeaking and excluding a drop of yellowish froth at each side of the prothorax. This

froth had a very faint but disagreeable taste which can be compared to the smell of a "sour" dishcloth.

5221. *Sphacelodes vulneraria* (Hbn.). Extension of range. A pair was caught at light on Big Pine Key in October.

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NYMPHALIDAE OF WISCONSIN

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Fernekes (1909) and Muttkowski (1907) compiled a list of over 1000 species of Lepidoptera, including Nymphalidae, found in the Milwaukee County area. The list was by no means a complete survey of the Lepidoptera of Wisconsin, nor was it entirely accurate for the Milwaukee area. Lack of extensive collecting, deficiency of accurate records, and absence of recent distribution studies have resulted in only generalized records on the distribution and range of Nymphalidae in Wisconsin.

Thus, during the summer of 1966 and continuing into the spring of 1968, a survey was conducted in an attempt to establish the distributive range of Nymphalidae in Wisconsin. Literature sources provided a preliminary list of Wisconsin Nymphalidae. Specimen records were then obtained from the collections of the University of Wisconsin, Northern Michigan University, University of Minnesota, Concordia College, Wisconsin State University at Stevens Point, and from the personal collection records of J. A. Ebner, Wm. E. Sieker, Stephen C. Kleene, and Kurt Johnson, as well as from my own collection.

Twenty-four species of Nymphalidae were obtained through personal collecting in various parts of Wisconsin, ranging from Bayfield County in the north to Dane County in the south. *Polygonia faunus, Polygonia progne, Phyciodes batesii, Phyciodes gorgone*, and *Melitaea harrisii* were added through reference to the collection of the Russel Laboratory, at the University of Wisconsin. Collection records of *Agraulis vanillae* and

Boloria freija were received from Wm. E. Sieker, Madison, and Kurt Johnson, Stevens Point. Records of *Anaea andria* and *Nymphalis californica* have also been reported from the State by J. A. Ebner, West Allis.

Thirty-three species representing eight subfamilies and fifteen genera have been collected within the boundaries of Wisconsin. *Polygonia gracilis* and *Polygonia satyrus* may also occur within the State. A specimen of the latter, in the collection at Northern Michigan University, was taken in northern Wisconsin. However, its presence has not been established due to lack of collecting in that part of the State.

The county records for individual species are available to the interested reader. The following are the generalized ranges of Wisconsin Nymphalidae:

Charaxinae

Anaea andria Scudder. At present recorded only from Racine Co., but may inhabit the southern third of the State.

Apaturinae

Asterocampa celtis (Boisduval & Leconte). Probably present in the entire State, but not yet recorded from the northwestern counties.

Asterocampa clyton (Boisduval & Leconte). Inhabits the southern two-thirds of the State.

Limenitidinae

Limenitis (*Limenitis*) *arthemis* (Drury). Occurs through most of Wisconsin, but its existence is doubtful in the southern extremities.

Limenitis (*Limenitis*) *astyanax* (Fabricius). Is found in the southern half of Wisconsin.

Limenitis (*Limenitis*) *archippus* (Cramer). Has a state-wide range.

Vanessinae

Vanessa atalanta (Linnaeus). Has a state-wide range.

Vanessa virginiensis (Drury). Has a state-wide range.

Vanessa cardui (Linnaeus). Has a state-wide range.

Junonia coenia (Hubner). Is scattered throughout Wisconsin.

Nymphalinae

Nymphalis vau-album (Denis & Schiffermuller). Has a state-wide range, however the species is most frequently collected in northern Wisconsin.

Nymphalis californica (Boisduval). Has only been collected once in Wisconsin, and that was in Door Co.

Nymphalis milberti (Godart). Has a state-wide range.

Nymphalis antiopa (Linnaeus). Has a state-wide range.

Polygonia interrogationis (Linnaeus). Has a state-wide range.

Polygonia comma (Harris). Has a state-wide range.
Polygonia faunus (Edwards). Has been collected in the northern counties of Door, Chippewa, and Marinette.
Polygonia progne (Cramer). Ranges throughout Wisconsin; however the species is more frequently collected in the northern territories.

Melitaeinae

Phyciodes (*Phyciodes*) *tharos* (Drury). Has a state-wide range.
Phyciodes (*Phyciodes*) *batesii* (Reakirt). Has been taken only in the northeastern counties of Bayfield, Brown, and Marinette.
Phyciodes (*Phyciodes*) *gorgone* (Hübner). Is scattered throughout Wisconsin.
Melitaea (*Microtia*) *harrisii* Scudder. Inhabits portions of eastern Wisconsin, being most frequently collected in the northern third of the State.
Melitaea (*Microtia*) *nycteis* Doubleday. Has a state-wide range.
Euphydryas phaeton (Drury). Has a state-wide range.

Argynninae

Boloria (*Clossiana*) *selene* (Denis & Schiffermuller). Has a state-wide range.
Boloria (*Clossiana*) *toddi* (Holland). Has a state-wide range.
Boloria (*Clossiana*) *freija* (Thunberg). Has only been collected in Bayfield, Oneida, and Portage counties, but may later be found to range throughout the northern counties.
Speyeria (*Speyeria*) *idalia* (Drury). Distributed throughout southern Wisconsin.
Speyeria (*Speyeria*) *atlantis* (Edwards). Distributed through the northern third of Wisconsin.
Speyeria (*Semnopsyche*) *cybele* (Fabricius). Has a state-wide range.
Speyeria (*Semnopsyche*) *aphrodite* (Fabricius). Has a state-wide range.
Euptoieta claudia (Cramer). Is scattered throughout Wisconsin.

Heliconiinae

Agraulis vanillae (Linnaeus). Has only been collected in Grant and Portage counties, but may later be found to range throughout the southern parts of Wisconsin.

Acknowledgments

I am grateful to Dr. R. D. Shenefelt and L. J. Bayer, the University of Wisconsin; Gordon D. Gill, Northern Michigan University; Dr. Ke Chung Kim, the University of Minnesota; George Senechal, Concordia College; Kurt Johnson, Wisconsin State University at Stevens Point; J. A.

Ebner, West Allis, Wisconsin; and Wm. E. Sieker, Madison, Wisconsin, for their cooperation in providing collection records.

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A NEW NAME FOR *PAPILIO ZETES* WESTWOOD, 1847, NEC LINNAEUS, 1758 (PAPILIONIDAE)

EUGENE MUNROE

Entomology Research Institute, Canada Department of Agriculture, Ottawa

J. O. Westwood (1847, p. 36, pl. 3, figs. 1, 1*) described *Papilio zetes* from St. Domingo. This was recognized as a valid species of *Papilio* by subsequent authors, e.g., Rothschild and Jordan (1906, p. 515), but was transferred by Munroe (1961, pp. 47, 51) to *Battus* Scopoli. D' Almeida (1966, p. 116) followed this placement.

Unfortunately *Papilio zetes* Westwood is a junior primary homonym of *Papilio zetes* Linnaeus (1758, p. 487), now placed in *Acraea* Fabricius, and it has no junior synonyms. Therefore, under Article 60(b) of the International Code of Zoological Nomenclature, the former name requires replacement. I propose ***Papilio zetides*, nom. nov.**, to replace *Papilio zetes* Westwood. *Papilio zetides* should be transferred to *Battus*, becomin *Battus zetides* (Munroe), **comb. nov.**

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NOTES ON THE OCCURRENCE OF TWO RARE LEPIDOPTERA IN SOUTH CAROLINA

In late May and early June of 1970, I discovered a colony of *Satyrium kingi* (Klots and Clench) in Dorchester County at the county line on highway 642 where Dorchester and Charleston counties meet. As far as I have been able to determine this is the first Dorchester County records, and possibly the first record for the state in the Coastal Plain.

In July, a colony of *Euphyes bimacula* (G. & R.) was found just east of Summerville, S. C. in Berkely County near the junction of U. S. A17 and I-26, and to the northwest of this junction. According to Klots (1951, A Field Guide to the Butterflies) this is well south of its supposed range.

RONALD R. GATRELLE, *35 Reddin Rd., Apt. 1, Charleston, South Carolina.*

VAN SOMEREN BUTTERFLY COLLECTION TO THE AMERICAN MUSEUM OF NATURAL HISTORY

This magnificent collection of the butterflies of East Africa, mostly from Kenya, Uganda, and north Tanganyika, plus the adjacent areas of southern Ethiopia, Somali, and eastern Congo, has been donated to the American Museum of Natural History. It represents over 60 years of work by Dr. V. G. L. van Someren, with the specimens being obtained both by catching and by rearing; it is one of the largest and most complete collections of butterflies from the above area. The collection consists of 22,931 specimens; of this total, 18,497 are butterflies; there are 258 slides of genitalia, and 4,176 specimens of early stage material, particularly of *Charaxes*. As far as I know, this is the largest single collection of African butterflies to come to the United States at one time.

The specimens of this collection have been studied and identified by many specialists and have been included in their revisionary studies on African butterflies. These include W. H. Evans' "A Catalogue of the African Hesperiidae" (1937), H. Stempffer's "The Genera of the African Lycaenidae" (1967), and Dr. van Someren's own "Revisional Notes on African *Charaxes*" (1963–1969, with more parts to be published), just to mention a few. Dr. van Someren has reared many species of *Charaxes* and has made a sizable collection of cast larval head capsules and of pupae; this valuable material came with the collection.

No holotypes or allotypes are included with the collection. Dr. van Someren has deposited his type specimens, as well as a portion of his butterfly collection, in the entomological section of the British Museum (Natural History).

FREDERICK H. RINDGE, *Dept. of Entomology, American Museum of Natural History, New York.*

A MELANIC ABERRATION OF *PHYCIODES THAROS* (NYMPHALIDAE)

A striking female aberration of *Phyciodes tharos* (Drury) emerged 29 May 1969 from a laboratory brood reared from a wild-inseminated female collected four miles east of Cedar Key, Levy Co., Florida, 29 March 1969. All rearing was done using a 16-hour daily photophase at 27° C and with *Aster ericoides* L. as the larval foodplant.

A comparison of the melanic female with a normal sibling female shows that all of the black pattern elements of both the dorsal and ventral wing surfaces have spread into the fulvous areas between them, leaving light pigmentation only in the central parts of normally fulvous areas. The ventral "pearl crescent" near the anal margin of the hind wing has been completely covered by dark pigmentation, but it

can be seen through the black scales and is otherwise normal. The coloration of the body and of the appendages has remained unaffected.

There is a melanic *P. tharos* female labelled "Norwich, Mass./30 July 1955/leg. M. Cady" in the Peabody Museum at Yale, but in this specimen the wing markings have become completely blurred and smudged. On the dorsal side there is extensive fulvous at the wing bases with the rest of the wing surface black. Ventrally only two of the forewing black markings appear on a clear yellow ground, and the hind wing is cream with a large central brown patch. The two melanic specimens are very different in the way that the wing patterns have been affected, and they may be the result of quite different effects (for example, environmental *vs.* genetic).

The Florida individual was the last to emerge in a brood of 158 individuals (87 ♂♂, 61 ♀♀), pupating and emerging several days after the last of its siblings. The melanism is thus correlated with a significant slowing in the rate of development, due probably either to a direct effect on the developmental rate or to a general lessening of vigor.

It is interesting to speculate on the possible inheritance of the form. The melanic was mated to a non-melanic sibling and produced a brood of about 40 adults, all of non-melanic appearance. Embryo mortality was high but normal for an F_1 of a sibling mating in this species; larval and pupal mortality were negligible. If the melanic form is genetic in origin, it is probably recessive.

CHARLES G. OLIVER, *Hope Dept. of Entomology, Oxford University, Oxford, England.*

A SPECIALIZED CASE OF COMMUNAL ROOSTING IN *PIERIS RAPAE* (PIERIDAE)

As a possible parallel to the report by Clench (1970, J. Lepid. Soc. 24: 117–120) it seems worthwhile to record my observations on a roosting aggregation of *Pieris rapae* (L.) in a garden at 2 Gulfview Rd., Blackwood, South Australia, in the foothills of the Mt. Lofty Range south of Adelaide, at an elevation of 800 feet. I lived at this address for five and one half years (1965–1970), during which time the following was observed.

P. rapae is abundant and multiple-brooded in this locality; the larvae feed upon a luxuriant patch of nasturtium (*Tropaeolum*) in the garden being described. Adults are on the wing from early spring (Sept.) to autumn (Apr.-May), reaching a peak during the summer period (late Nov. to early March). In this garden grows a small tree (height approximately 10 feet; shape roughly pyramidal; foliage cover fairly open) of *Pittosporum undulatum* Vent. var. *variegatum* (PITTOSPORACEAE). The important feature of this tree, with respect to the account that follows, is the coloration of its leaves. The leaves of this smaller-growing garden variety of *P. undulatum* are a pale greenish-white with contrasting white margins. The overall effect of the tree color is whitish-green; seen in the warm yellowish rays of late afternoon sunshine, just prior to sunset, these leaves light up with a faintly yellowish or cream-green tinge which is very close to the shade on the visible areas of the undersides of *P. rapae* wings when the butterflies are in their normal resting position with the wings closed over the dorsum. This *P. undulatum* tree was growing among other nearby trees, shrubs, and vines, but was in an opening where it received direct sun for most of the day. During sunny summer days, adults of *P. rapae* flew through this garden by the dozens, often five or more being visible at one time within the boundaries of the garden. Many of them would fly over and around this tree during the midday hours, even then showing somewhat more attraction to it than

to most other vegetation in the garden. Their primary attention, however, was centered around the extensive nearby *Tropaeolum* patch during this part of the day.

As late afternoon approached, on most sunny days, *many* individuals would be seen circling, alighting upon, or flying in and out of the small *Pittosporum* tree. Their concentration around this particular tree would become quite noticeable, although a few would also be seen flying around other plants in the same garden, preparatory to settling for the night. As the sun came closer to the horizon, more and more individuals settled in this tree. At first there would be much alighting and taking off again, and fluttering slowly about, before final settling took place.

Once at rest among these whitish-green leaves, the butterflies were very hard to see at a passing glance, although careful scrutiny would show up some of them. Numbers settling into this tree would often approach 10 or more individuals by sunset, whereas other nearby vegetation would only attract the odd individual. A person passing the *Pittosporum* tree in late afternoon, at the right time, would often cause a small "cloud" of *P. rapae* to burst from the tree as he passed by; later (early evening) they would not arise from the tree unless it was knocked, or a very sudden movement was made at close range. During the period of "settling in" I noticed that most of them landed on the western (sunny) side of the tree, and among its upper branches, wherever the last weak rays of sunshine remained longest.

This case of "communal" roosting is probably more or less explained in the last paragraph of Clench's discussion. It seems likely that the distinctive foliage coloration of this particular variety of *P. undulatum*, plus its favorable location with respect to the late rays of sunlight, combined to provide a special attraction for *P. rapae* under the influence of late afternoon sunlight. In most *other* circumstances, I strongly suspect that this pierid would show little or no communal roosting behavior. At best they might show only a slight attraction for one type of roosting situation over some others, but they would probably not form any noticeable aggregations on any single plant.

No marking of individuals was undertaken during these summers, so I cannot say whether the same individuals came to roost in this same tree night after night, or if there was any tendency to use certain leaves or stems repeatedly in preference to others on the same tree. I would guess, however, that a fairly large percentage of different or new individuals formed the aggregation in this tree each evening. Probably the turn-over was very high each day, as the butterflies wandered through this residential area, from garden to garden. Those finding themselves (by late afternoon) in the garden described, would naturally gravitate toward the most attractive roosting place which, in this instance, happened to be the small creamy-green *Pittosporum* tree.

NOEL MCFARLAND, *129 Gloucester Ave., Belair, South Australia.*

NOTES ON THE CONFUSION BETWEEN *LETHE CREOLA* AND *LETHE PORTLANDIA* (SATYRIDAE)

There has been confusion between *Lethe creola* (Skinner) and *Lethe portlandia portlandia* (Fab.) in not only private collections but also in institutions and in literature.

This confusion is evidenced by the fact that the female of the type series of *creola* from the Skinner collection, which is now in the Carnegie Museum, was found to be a female of *L. portlandia* by Gillham and Ehrlich. Without going further into

this aspect of the matter I will simply refer the reader to the 1970 article by Roderick R. Irwin the (Jour. Lepid. Soc. 24: 143–151).

While collecting these two species in South Carolina (1970), I found a constant pattern in the flight habits of the two species. It became evident why there has been so much confusion between them. Confusion exists in regard to the females; the males of the two species are easily distinguished. Many of the earlier collectors, especially in Louisiana where the type and allotypes of *creola* came from, must have encountered the same situation which I did. The habitat of *creola* is often an inaccessible area of swampy, bushy, cain-filled undergrowth. Naturally one would tend to collect in the more open areas in this type of terrain. In the open areas where collecting is more easily done you will find a preponderance of male *creola* and female *portlandia*; both *portlandia* males and *creola* females are rare.

The following records were taken from 9 April to 18 Oct. 1970. Of 40 female *portlandia* examined, 29 were collected in more open areas, such as along paths; 11 were taken in denser areas, e.g. 20 feet or more away from clearings. Only two male *portlandia* were taken in open spaces whereas ten were caught in the denser areas.

Of 24 male *creola* caught, 15 were found in the open areas, nine in dense areas. Of seven female *creola* found, five were in dense areas, only 2 in more open terrain.

The majority of specimens were released. Due to the difficulty in moving around in the denser areas many specimens seen there escaped capture. The tendency of both species to occur in different areas was not affected with regard to the time of year but specimens were more difficult to capture in the fall.

RONALD R. GATRELLE, *35 Reddin Rd., Apt. No. 1, Charleston, South Carolina.*

REMARKS ON "DISTRIBUTIONAL NOTES ON THE GENUS *MESTRA* (NYMPHALIDAE) IN NORTH AMERICA"

I wonder if Mr. Masters is not attaching undue importance to the occurrence of *Tragia* in his paper entitled as above (1970, *Journal Lepidopterists' Society*, 24: 203).

Five species of East African Eurytelinae have their food-plants recorded, viz. *Byblia acheloia* Wllgrn. and *B. ilithyia* Drury feeding on *Tragia brevipes* and *Dalechampia hildebrandti*, *Eurytela hiarbas* Drury and *E. dryope* Cr. feeding on *Dalechampia hildebrandti* and *Ricinus communis* and *Neptidopsis fulgurata* Bsd. recorded from *Dalechampia hildebrandti* only. The Indian *Ergolis ariadne* Johan. feeds on two species of *Tragia*, whilst *E. merione* Cr. feeds on Castor (*Ricinus communis*).

I cannot help feeling that *Mestra amymome* may also have one or more alternative foodplants.

D. G. SEVASTOPULO, *P. O. Box 5026, Mombasa, Kenya.*

DRAGONFLY ATTACKS *LIMENITIS* DEFENDING ITS TERRITORY

On June 23, 1970, while collecting *Limenitis archippus floridensis* Strecker near Folkston, Georgia, I observed a rather unusual sequence of events involving a male *Limenitis* and a large dragonfly.

The *Limenitis* flew over a small shaded waterhole along Route 252. As I pursued it, I observed the dragonfly dive at the *Limenitis* who evaded it and landed on a cypress branch. After resting, the butterfly soared slowly over the open water. The dragonfly swooped down and grasped the butterfly, then carried it to the water where it was released.

The stunned butterfly fluttered weakly to a nearby branch, rested there a considerable period of time flexing its wings frequently. The dragonfly soared past it several times feigning attack each time the butterfly folded its wings. A final attack by the dragonfly knocked the butterfly to the ground; it remained a few seconds

flexing its wings, then retreated into the densely wooded swamp with the dragonfly in pursuit.

Dr. Clifford B. Knight states in *Basic Concepts of Ecology*, p. 157: "Dragonflies will establish a linear territory along a stream or in the vicinity of a body of water that they patrol and defend against invasion by other members of their species." Territoriality is normally intraspecific—could this unusual behavior suggest another predator for the tasty *Limenitis* or the extension of territoriality to an interspecific activity by the dragonfly?

During the past ten years, I have collected thousands of *Limenitis*. Always these individuals were found in association with water, and in the South with the ever present dragonfly which apparently shares its habitat. In most cases, this appears to be a harmonious relationship.

THOMAS R. MANLEY, *Bloomsburg State College, Bloomsburg, Pennsylvania.*

THE OCCURRENCE OF *VANESSA CARDUI* IN MISSISSIPPI AND TENNESSEE[1]

C. B. Williams (1970, Jour. Lepid. Soc. 24: 157) stated that *V. cardui* "is not often recorded in the southeast, though if this is due to a real rarity or to lack of interest is not certain." Speaking of its occurrence in 1952, he wrote, "There are however no records of abundance from Texas or from any of the Gulf States except Mississippi, where it was said to have been 'abundant'." He concluded with a plea for sharing one's observations. I give here observations made in Mississippi and Tennessee.

V. cardui was first recorded from Mississippi by Weed in 1894 as taken by him in the northeastern part of the state during the three previous years. He reported it rarer than *virginiensis*. Mather and Mather in 1958 reported having found it in all months except January, May, June, and December. Records are now available for May, June, and December, leaving only January without records. Localities were known in nine counties in all sections of the state. It is probably their record of 1952 occurrence as "abundant" that is referred to by Williams. All data now available to me for Mississippi occurrences are tabulated below in terms of number of recorded occurrences per month. For the years not listed there are no recorded occurrences.

	F	M	A	M	J	J	A	S	O	N	D	
1947	–	–	–	–	–	–	–	1	–	–	–	1
1948	–	–	–	–	–	–	–	1	–	–	–	1
1949	–	–	1	–	–	–	1	1	1	–	–	4
1952	1	3	1	2	–	1	1	1	3	2	1	16
1953	–	2	–	–	–	–	1	–	–	1	–	4
1954	–	–	1	–	–	–	–	–	2	2	–	5
1957	–	–	–	–	–	2	3	1	1	–	–	7
1958	–	–	–	1	2	4	4	–	–	–	–	11
1960	–	–	–	1	–	–	–	–	2	–	–	3
1965[2]	–	–	–	–	–	–	2	1	–	–	–	3
1968[2]	–	–	3	4	1	–	1	1	–	1	–	11
1970[2]	–	–	–	–	1	–	1	2	1	1		6
	1	5	6	8	4	7	14	9	10	7	1	72

[1] Contribution No. 190, Bureau of Entomology, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville.

[2] Includes data furnished by Mr. Charles T. Bryson, Mississippi State University.

Mr. Harry C. Monk, Nashville, Tenn. has tabulated his observations of the occurrence of *V. cardui* in that area (Davidson County) and has granted me permission to include them in this report. In the following tabulation of number of days in any one month that *V. cardui* was observed, a day is counted regardless of the number of individuals seen or the number of localities at which the species was seen. Data through 1970 are included. He has one December record: 8 December 1952; this is the only year for which there is a December record for Mississippi.

	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	
1954	–	–	1	9	4	24	17	2	57
1955	–	–	–	–	–	3	3	–	6
1956	–	–	–	–	2	1	–	–	3
1957	–	–	–	9	11	19	10	1	50
1958	–	–	3	13	10	17	1	1	45
1959	–	–	1	1	–	2	–	–	4
1960	–	–	–	4	11	9	5	–	29
1961	–	–	–	2	1	–	–	–	3
1962	–	–	–	–	3	4	2	3	12
1963	–	–	2	2	7	6	9	1	27
1964	–	–	–	–	2	2	7	1	12
1965	–	–	–	1	6	6	2	–	15
1966	1	2	7	1	8	7	12	2	40
1967	–	–	–	–	–	–	5	–	5
1968	4	6	10	5	25	13	9	–	72
1969	–	–	–	–	–	–	1	–	1
1970	–	–	1	2	4	5	2	1	15
	5	8	25	49	94	118	85	12	396

BRYANT MATHER,[3] *213 Mt. Salus Dr., Clinton, Mississippi.*

[3] Research Associate, Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

BOOK REVIEW

THE ENGLISH LEPIDOPTERA OR THE AURELIAN'S POCKET COMPANION, by Moses Harris. 1775, 66 pp. + i–xv, 1 coloured plate. Reprinted 1969 by E. W. Classey Ltd., Hampton, Middlesex. Distributed in North America by Entomological Reprint Specialists, P.O. Box 77971, Dockweiler Station, Los Angeles, Calif. Price $9.60 U.S.

An introductory section of the book is devoted to the collection, rearing and preservation of moths and butterflies. The remainder of the text is arranged in the form of a table which lists for 415 species of British Lepidoptera: common names, food plants, seasonal periods of pupation and emergence, wing expanses, habitats, and diagnostic macular features. The last column in the table of data lists the Linnaean names for each species and numbers them according to the tenth edition of the *Systema Naturae*. A coloured frontispiece illustrates the numerial system of designating wing veins and cells. The book will be a particular interest to the bibliophile.

D. F. HARDWICK, *Editor.*

ADDITIONAL RECORDS OF *PATRICIA DEMYLUS GEMELLUS* FOX (ITHOMIIDAE)

Patricia demylus gemellus Fox was described (1960, Jour. New York Ent. Soc. 68: 152–156) from only three known specimens (two in the British Museum and one in the Museum of Comparative Zoology), all males, and all from Bolivia.

I have obtained eleven additional specimens in consignments from Franz Steinbach of Cochabamba, Bolivia. The first eight of these (including four males and two females from El Limbo, Prov. Chapare, Cochabamba, Bolivia, 2,200 meters and two males from Alto Palmer, Prov. Chapare, Cochabamba, Bolivia, 1,100 meters) were determined and examined by Richard M. Fox before his death in 1968. He stated that they were the only known specimens outside of the type series and contained the only known females.

In 1967 I received three additional specimens: a female from Cristal Mayu, Prov. Chapare, Cochabamba, Bolivia, 600 meters (the lowest known elevation) and two males from El Limbo, Prov. Chapare, Cochabamba, Bolivia, 2,200 meters, March 1967 (the only known specimens with collecting dates).

The genus *Patricia* Fox is better known as *Athesis* Kirby following usage in Seitz (1910, Die Gross-Schmetterlinge der Erde, vol. 5). Fox considers *Athesis* monotypic, containing only *clearista* Doubleday & Hewitson; with *dercyllidas* and allies, including *demylus*, being removed to *Patricia*. The genus consists of three very rare species with Andean distribution in Colombia, Peru, Ecuador and (*demyllus* only) Bolivia.

I have placed a pair of my specimens in the Carnegie Museum collection in Pittsburgh, and two males in the collection of Herman Real at San Mateo, California. The remainder, for the present time, are retained in my personal collection.

JOHN H. MASTERS, *Lemon Street North, North Hudson, Wisconsin.*

FIRST RECORDS OF *BOLORIA EUNOMIA* (NYMPHALIDAE) IN WISCONSIN

The first record of *Boloria eunomia* (Esper) was incorrectly reported by me in the News of the Lepidopterists' Society (Number 3, 1969). The correct data for this record, consisting of two males and one female, is 23 June 1968, in a bog along highway 111 between Catawba and Phillips, Price County, Wisconsin—instead of, as originally reported, Rusk County, Wisconsin.

1970 collecting yielded some additional Wisconsin localities for *Boloria eunomia*. Fay Karpuleon, of Eau Claire, collected a short series in a bog near Cornell, Chippewa County on 5 June 1970 and added additional specimens during the following week; this is the southernmost locale where this species has been taken in North America east of the Rockies. On 14 June, I joined him and we collected additional specimens (still fresh) in the bog at Cornell, but attempts to locate specimens in bogs further north were unsuccessful. On 27 June 1970, I secured a few specimens in three bogs between Toni and Big Falls Flowage in Rusk County and in a bog along highway M in extreme southeastern Sawyer County, all of which were somewhat flown. Later the same day, I collected a very worn female in the Cornell bog in Chippewa County, thus documenting a flight season of at least 22 days for the species at this particular locality in 1970. The flight season for *Boloria eunomia* is usually regarded as quite short (e.g. Gray, 1965, J. Lepid. Soc. 19: 184–185).

The range of *Boloria eunomia* is probably more extensive in Wisconsin than these scant records indicate. I have found, in Minnesota, that it is one of the more widespread, bog-restricted butterflies, and I expect that it occurs throughout northern Wisconsin in sphagnum bogs. The Wisconsin population of *Boloria eunomia* belongs to the subspecies *dawsoni* (Barnes & McDunnough).

JOHN H. MASTERS, *Lemon Street North, North Hudson, Wisconsin.*

ATTRACTION OF *SPEYERIA APHRODITE* TO ULTRA-VIOLET LIGHT

Hocking Hills is a combinative park, forest and conservation area in southern Ohio, approximately 60 miles from Columbus. In 1968, 1969 and 1970, from the beginning of June through August, Lepidoptera were collected by means of long wave ultra-violet light. The four lights, of the "portable safari-type" were placed five feet apart and faced in opposite directions. Collecting began at dusk and continued until approximately 5:00 a.m. on misty evenings with the temperature not below 60 degrees F. nor above 85 degrees F. During 1968 and 1969 occasional *Papilio polyxenes asterius* (Stoll) and *Papilio glaucus* (Linnaeus) were attracted to the ultra-violet, while no specimens of *Speyeria aphrodite* (Fabricius) were so attracted; all three species were readily abundant during the day.

In contrast, each collecting night in 1970 yielded four to nine *S. aphrodite* (sexes about evenly distributed) at the light, although few *S. aphrodite* were observed during the day. Concurrently, no specimens of *P. polyxenes asterius* or *P. glaucus* were attracted to the ultra-violet light, but these were abundant during the day. The authors find these observations intriguing. Perhaps further investigation of the attraction of diural Lepidoptera to various wave lengths of light would be profitable.

M. S. CANNON AND G. A. PALKUTI, *Dept. of Anatomy, Ohio State University, Columbus.*

OENEIS JUTTA (SATYRIDAE) IN WISCONSIN

There have been no satisfactory published records for *Oeneis jutta* Hübner in Wisconsin. F. R. Arnhold recorded it (Season's Summary for the Lepidopterists' Society for 1954) from Chippewa Falls, Chippewa County, which is further south than it would be expected to occur; and Masters and Sorensen (1968, Ent. News, 79: 82) referred to specimens from Hines County, Wisconsin; these were specimens in the Frank Chermock collection, presumably collected by L. Griewisch, but unsatisfactory as records because there is no Hines County in Wisconsin.

During 1969 and 1970, Fay Karpuleon of Eau Claire, Wisconsin and I collected examples of *Oeneis jutta* from a number of localities in Wisconsin including: Chippewa County, near Cornell, 5, 8, 14 and 27 June 1970; Oneida County, near Rhinelander, 7 June 1970; Price County, near Catawba, 20 June 1969; and Rusk County, near Big Falls Flowage 14 and 27 June 1970, near Bruce 20 June 1969, and near Toni 14 June 1970. In addition, Keith S. Brown Jr. of Rio de Janeiro reports (in personal communication) having taken *Oeneis jutta* in Forest County, Wisconsin during 1962.

Oeneis jutta is a bog obligated species in Wisconsin and surrounding areas, and should have a widespread occurrence in the black spruce/sphagnum bogs of northern Wisconsin. The species has a biennial life cycle and the heaviest adult flights are expected in odd-numbered years as in Minnesota. The Wisconsin population of *Oeneis jutta* belongs to subspecies *ascerta* Masters & Sorensen.

JOHN H. MASTERS, *Lemon Street North, North Hudson, Wisconsin.*

SOME SPHINGIDAE OF HONDURAS

Most of the thirty-four species of Sphingidae listed in this article were collected by the author from 1968–1970 in Honduras, Central America. All the Sphingidae were taken from the following five locations: (1) La Ceiba, (2) San Pedro Sula, (3) La Lima, (4) Tegucigalpa, and (5) Zamorano. The thirty-five species have been listed alphabetically and numbered according to the locations where they were collected. See Map of Honduras (Fig. 1) for approximate location of these sites. Mr. William E. Sieker of Madison, Wisconsin determined the Sphingidae listed.



Fig. 1. Map of Honduras showing the locations where the Sphingidae were collected. Locations indicated: 1, La Ceiba; 2, San Pedro Sula; 3, La Lima; 4, Tegucigalpa; 5, Zamorano.

The five locations where the Sphingidae were collected are described below:

La Ceiba. La Ceiba is a seaport of the Caribbean Sea. All my specimens were taken the nights of July 28, 29, and 31, 1970. All specimens were caught in 'Colonia El Sauce', being attracted to the big street lights. They were most active between 8:00 and 9:00 p.m. This 'colonia' or residential area at the edge of the city, is near a river and bordered by thick vegetation. The night of July 31 it drizzled around 9:00, and the Sphingidae and large noctuids were very active. After flying around the lights they would apparently tire and drop to the grass and pavement where they became "easy picking."

San Pedro Sula. San Pedro Sula faces the rich Sula Valley with its back to the mountain. The Sula Valley contains plantations of bananas, sugar cane, and citrus groves. Most of my Sphingidae were taken at the University which is located outside the city and surrounded by wooded areas. The sphingids were attracted to the lights and easily picked off the windows and walls in the evening.

La Lima. La Lima is located 14 kilometers southeast of San Pedro Sula in the Sula Valley. My specimens were taken at the tennis courts of the United Fruit Company on August 26 1970 between 8:00 and 9:30 p.m. The bright lights attracted quite a number of sphingids. A river flows past the tennis courts.

Tegucigalpa. Tegucigalpa is a highland plateau, 3200 feet in elevation, surrounded by pine forest. The Tegucigalpa specimens were attracted by street and building lights. Many were taken from a high wall along the Choluteca River. Those too high to reach with a net I knocked down by throwing the sheath of a hunting knife at them. When touched they would drop straight down into the awaiting open net.

Zamorano. The few specimens I have from Zamorano were caught by students of the Pan American Agricultural School. This school is located in a valley 36 kilometers east of Tegucigalpa. It has several cloud forest peaks around it. The Sphingidae were attracted to the lights of the buildings.

The specimens collected are listed below:

Species	Location No.	Species	Location No.
Amphimoea walkeri Boisd.	1	*Phlegethontius rustica* Fabr.	1, 4
Celerio lineata Fabr.	1	*Phlegethontius sexta* Johan.	4
Cocytius duponchel Doey	1	*Pholus auchemolus* Cramer	4
Epistor ocepete Linné	4	*Pholus capronnieri* Boisd.	5
Erinnyis alope Drury	1	*Pholus labruscae* Linné	1
Erinnyis crameri Schaus	1	*Pholus ogliguus* R. & J.	1
Erinnyis ello Linné	1, 3	*Pholus vitis* Linné	1, 3, 4
Erinnyis lassauxi Boisd.	1	*Protambulyx strigilis* Linné	2, 4
Erinnyis oenotrus Stoll.	1, 3	*Pseudosphinx tetrio* Linné	4
Grammodia caicus Cramer	3	*Sphinx merops* Boisd.	2
Hemeroplanes parce Fabr.	4	*Xylophanes libya* Druce	4
Herse cingulata Fabr.	1	*Xylophanes chiron nechus* Cramer	1
Pachylia ficus Linné	1, 2, 4	*Xylophanes neoptolemus* Stoll	1
Pachylia resumens Walker	2, 4	*Xylophanes pluto* Fabr.	4
Phlegethontius florestan Stoll.	1	*Xylophanes porcus continentalis* R. & J.	4
Phlegethontius incisa Walker	4	*Xylophanes tersa* Linné	2, 3, 5
Phlegethontius muscosa R. & J.	4		
Phlegethontius occulta R. & J.	2		

ROBERT D. LEHMAN, *Route 2, Orrville, Ohio.*

BOOK REVIEWS

THE INSECT REALM, by Charles L. Hogue and Fred S. Truxal. 1970, 99 pp. + i–viii. Los Angeles County Museum of Natural History. Price $2.00 U.S.

This attractive little book was nominally produced to serve as a guide to the *Hall of Insects* at the Los Angeles County Museum. Such an abundance of information is presented in concise form, however, that the book could well serve as a text or reference in high school biology classes. Succesive chapters are devoted to the position of insects in the animal kingdom, to morphology and phylogeny, to growth and development and to the insect environment. Other sections deal with beneficial and injurious insects and the making of an insect collection. The chapter on classification gives brief and illustrated diagnoses of the principal insect orders. The book should be owned by all neophyte entomologists.

D. F. HARDWICK, *Editor.*

A FIELD GUIDE TO THE BUTTERFLIES OF BRITAIN AND EUROPE, by L. G. Higgins and N. D. Riley, with color illustrations by Brian Hargreaves. Collins, London. 380 pp, 371 maps, 60 colored plates. September, 1970. 42s.

It has been 85 years since there was published in English as complete a study of the butterflies of western Europe and the British Isles as is presented in this splendid volume. I am sure that it will be the standard guide to those butterflies

for the rest of this century and well into the next. The book follows the pattern first established many years ago by Tory Peterson in his bird guides for North America. The layout is the same as you find in Klots's Field Guide for the butterflies east of the Great Plains.

The two authors of the new guide are among the most able Lepidopterists in the world. Higgins's careful studies of Old World Melitaeinae brought order to a most confusing array of butterflies. His personal collection of European butterflies is the best among all privately held collections. In fact, of the over 720 butterflies illustrated in this volume 700 are from Higgins's collection. Dr. Higgins personally collected by far the major part of his cabinet. Thus he knows intimately the habits and behavior of the species within the fauna about which he has written. Riley has been associated with the butterfly collections of the British Museum (N. H.) since 1911! He served as Keeper of the Department of Entomology from 1932 to 1955. He edited the *Entomologist* for 36 years. No other book about butterflies has behind it the amount of wisdom that guarantees this one.

The families are arranged in a manner that was in vogue some decades ago and still is considered the proper ordering by most amateur European collectors. While it differs from that used in the *Zoological Record* and from dos Passos's inversion of that order, it is no less useful. It is the same as that used by Holland in his *Butterfly Book*.

The authors were faced with a fantastic task winnowing the hundreds of subspecific names that have been proposed for European butterflies. They settled upon retaining only those that represent well-defined taxa and eliminated the minor local varieties. Nowhere is this better shown than in their treatment of the genus *Parnassius*. They devote two and a half pages to the genus and reduce this far over-named group of butterflies to seven subspecies of *apollo*, two of *phoebus* and two of *mnemosyne*.

Careful reading of this book shows that there are striking differences between the butterfly faunae of western Europe and North America north of Mexico. Part of this may be related to the more uniform climate of the Old World area when compared with that of the New World area. If the volume considered its eastern boundary the Ural Mountains instead of excluding the U.S.S.R., except for the Baltic states, more environmental diversity would have been included. The exclusion is reasonable since few if any western Europeans will be at liberty to collect freely in U.S.S.R. A summary of faunal differences is presented below:

Group	Western Europe			U S and Canada	
Papilionidae	11	2.9%		28	4.1%
Pieridae	41	10.8%		59	8.8%
Danaidae	2	0.5%		5	0.7%
Libytheidae	1	0.3%		2	0.3%
Nymphalidae	68	17.9%		147	21.5%
Satyridae	113	29.8%		47	6.9%
Nemeobiidae	1	0.3%	Riodinidae	19	2.8%
Lycaenidae	101	26.6%		133	19.5%
Hesperioidea	41	10.8%		242	35.4%
	379	99.9%		682	100.0%

Notice that there are many more satyrids in Europe than there are skippers. The reverse is true in the North American area. Satyrids and skippers compete for grasses as food in the larval stages. This difference is made more striking when we compare Hesperiinae, the grass-feeders, in the two areas. We have 128 species, the Europeans only 12. We cannot blame restriction of grasslands or prevalence of farmed lands for the small number of Hesperiinae in Europe. The satyrids prove that

there is ample food for a large and varied population of grass-feeders. I suspect that it is just a case of competition that has existed for many millenia and probably relates to refugia during the ice advances during the Pleistocene Epoch.

The European subregion is cut off from the tropical faunal regions by deserts and extraordinarily high mountains. This might be used as an explanation for the somewhat smaller European nymphalid array than is found in America north of Mexico. Here there is continuous land connection between the tropics and the temperate areas. The north-south pattern of American mountain ranges also may influence this difference. At first glance the Lycaenidae seem to deny such reasoning. When this family is looked at from the subfamily rank quite a different picture developes:

Subfamily	Western Europe		U. S. and Canada	
Theclinae	16	15.8%	80	60.2%
Gerydinae	0		1	0.7%
Lycaeninae	11	10.9%	16	12.0%
Plebejinae	74	73.3%	36	27.1%
	101	100.0%	133	100.0%

The dominance of Theclinae in the United States and Canada and the dominance of Plebejinae in western Europe make the species arrays of the two regions quite different. Continuity with the tropics, the stronghold of Theclinae, probably explains the large number of hairstreaks in our fauna. The very large number of blues in the European fauna may be real or it may be a figment of taxonomic philosophy in the two listings—Higgins & Riley vs. dos Passos. In turn, each of these is strongly influenced by recent regional taxonomic research. Stempffer and others in Europe are far ahead of anyone in North America in understanding of the Plebejinae. I have a strong suspicion that when parity of intelligence is reached for this subfamily the number of North America species will be increased. We have tended to turn to subspecies designation whereas the Europeans have demonstrated specific distinctions among taxa that are superficially much alike. Perhaps more than a little of our error has been blind acceptance of work published. We need much more to inquire critically before accepting the work of others.

Notice of occurrence in North America is included among the brief notes on range for the holarctic species found in western Europe. Such notice is made for 38 species. In four cases the relationship is not usually recognized in North America: *Pontia chlorodice beckeri* W. H. Edwards, *Pontia callidice occidentalis* Reakirt, *Euchloe ausonia ausonides* Boisduval and *Everes argiades comyntas* Godart. The last of these needs verification. Three species in the European fauna which we acknowledge in ours are not noted as such in Higgins & Riley. These are *Lycaeides argyrognomen* Bergsträsser, *Vacciniina optilete* Knoch and *Agriades glandon* de Prunner. I wrote to Higgins about these cases and he replied that in the case of the first two he had been unable to dissect North American specimens and therefore omitted reference to them. The omission of *glandon* was accidental. Higgins had collected material in Hall Valley, Colorado, when he visited me some years ago. At that time he remarked upon how close to *glandon* is *rustica*.

Although written primarily for the amateur collector in Europe this book will be found of value to collectors in North America. I recommend it highly to anyone who is interested in taxonomic studies, zoogeography and the biology of butterflies.

F. MARTIN BROWN, *Fountain Valley Rural Station, Colorado Springs, Colorado.*

CORRECTION

Vol. 24, no. 4, page 254, line 27: Under *Zamagiria australella* (Hulst) read "The type is in the American Mus. Nat. Hist." for "The type is in the U.S. Nat. Mus."

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Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Shorter articles are favored, and authors will be requested to pay for material in excess of 20 printed pages, at the rate of $17.50 per page. Address all correspondence relating to the *Journal* to: Dr. D. F. Hardwick, K. W. Neatby Bldg., Central Experimental Farm, Carling Ave., Ottawa, Canada.

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COMSTOCK, J. A. 1927. Butterflies of California. Los Angeles, Calif. 334 pp.
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Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA
by CYRIL F. DOS PASSOS

Price, postpaid: Society members—$4.50, others—$6.00; uncut, unbound signatures available for interleaving and private binding, same prices; hard cover bound, add $1.50. Revised lists of the Melitaeinae and Lycaenidae will be distributed to purchasers free.

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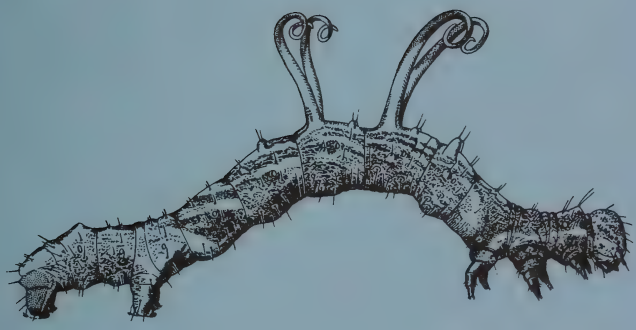
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Volume 25 1971 Number 3

The Lepidopterists' Society, Presidential Address

THE LEPIDOPTERA IN SCIENTIFIC RESEARCH

E. B. FORD, F. R. S.
Oxford, England

Read by Dr. J. W. Tilden at 21st Annual Meeting of
the Lepidopterists' Society in Carson City, Nevada
June 21, 1970

There are several reasons why the Lepidoptera provide material especially well suited to certain aspects of scientific research, in particular, perhaps, those within the field of ecological genetics. In the first place, one must mention the beautiful colour patterns of the imagines, which make it possible to analyse many components of their variation with especial ease and efficiency. Secondly, and no doubt originating from their striking aesthetic charm as well as their dramatic metamorphoses, butterflies have been one of the two animal groups most studied by generations of naturalists (birds being the other). Thus it comes about that we possess an immense fund of information on their ecology; these insects really have attracted more attention and for a longer period than any others, and the knowledge so obtained is of practical importance as a background for many types of biological research. It has indeed gradually accumulated until Lepidopterists have found the need to establish an International Society such as ours, in which the old natural history is transformed into an important branch of modern science. Yet let us not forget the entomologists of an earlier age. Some who were collecting butterflies and moths 120 years ago have been my personal friends and I know what fine field workers they were: their store of information, largely centred upon habit and behaviour, for the most part died with them, but it was great.

When we consider the impact of the Lepidoptera upon scientific research, one point strikes us at the outset or else is accepted as a basis inherent in the material we use: that is to say, their taxonomy. For if

we are to study any large assemblage, of whatever kind, it is necessary to classify it hierarchically. In doing so we must create some system giving us confidence in the names applied to the groups we use. It is perhaps invidious to single out any of those who have laboured to establish the nomenclature of the Lepidoptera. However, I would at least mention Mr. Francis Hemming, whose death some years ago was so serious a blow to this work, and Dr. C. F. dos Passos, of our own Society, to whose studies in this field at the present time taxonomy owes so much.

But what of the groups which the taxonomist names? We are all aware that though many possible classifications could be applied to them, that in general use is based upon relationship, so that it reflects one important aspect of reality; that is to say, evolution. It is our aim that the Lepidoptera placed in any one taxonomic division, whether it be small or great, species or family, should be more closely related to one another by actual descent than they are to any other organisms upon earth. Thus if the arrangement be represented diagrammatically, the result should produce a geneological tree.

We should certainly enquire whether that object, so basic to our endeavours, has been attained. Is the classification of butterflies and moths something more than a man-made convenience; does it indeed reflect affinity? We have a fair guarantee in that matter arising from the work of taxonomists themselves, who generally take into account the widest range of characters in making their decisions: morphological and physiological and in all the stages of the life history. But we can test its success when we extend to it a new criterion. We shall be on sure ground if independent evidence supports conclusions reached in ignorance of it.

Many years ago it seemed to me worthwhile to seek such confirmation. I obtained it by examining the chemistry of the wing pigments of butterflies and moths. These indeed proved to be strictly related to a classification which had taken no account of them. We have time to cite one instance only. Consider the flavones: these are non-nitrogenous pigments, ranging from deep yellow to ivory-white and derived ultimately from plants. Certain Lepidoptera make use of them to colour their scales, others do not. But those which employ them in that way are not scattered at random among the rest. Thus in the family Pieridae, flavones are never found except in the sub-family Dismorphiinae, and even there in but a proportion of the species (19 out of 58 tested: from a total nominally assessed as 108). Yet, with one exception independently admitted to be a taxonomic error, those in which they occur had been grouped together, although this particular quality which they share was unknown

to the entomologists who classified them (Ford, 1941); many other similar corroborations have subsequently been obtained.

Bearing these advantages in mind, the Lepidoptera have naturally been extensively used in scientific research, and a few examples of the problems they have helped to illuminate may briefly be considered here. We may first take the question of selection-pressure, and indicate two of the instances in which it has been evaluated.

The butterfly *Maniola jurtina* L., which is single brooded in Britain and most of Europe, has provided information on this subject. A criterion of that insect's adaptive adjustment is supplied by the spots on the underside of the hind wings. These may be absent or present in any number up to five, arranged as a curving submarginal row. They are controlled by polygenes which influence also other characteristics of greater importance to the organism and of these the spots may be taken as an outward and visible sign. Thus they affect the date of emergence, the more spotted specimens appear earlier, and also affect liability to destruction by certain parasites. These polygenes moreover, play an important part in adjusting the gene-complex to the needs of the population. When the butterflies are reared in a cool laboratory, with a temperature fluctuating in the region of 15° C, the heritability of spotting is 0.83 in the females and 0.14 in the males (McWhirter, 1969). At higher temperatures, the environmental component, so much greater in the males than in the females, is reduced; for at 22° C heritability actually approaches 1.0 in the females and it reaches 0.4 in the males. Thus selection has much genetic variability on which to operate.

We may concentrate here upon the female spot-frequencies since, being subject to greater major variability, they are more diagnostic than those of the males, which are nearly always unimodal at two spots. Not so the females, in which the spot-frequencies are diverse and characteristic.

The Isles of Scilly are an archipelago in the Atlantic 30 miles from the south-western extremity of England. We have studied *Maniola jurtina* upon a number of the Islands there, some large (682 acres or more), others small (40 acres or less). The difference in area between the two types is, therefore, at least 17 times. Female spotting differs greatly from one to another of the small Islands (it may be unimodal at 0 or at 2, or bimodal with the greater mode either at 0 or at 2), retaining its characteristic value on each, year after year. It is, however, similar on the major areas of all the large islands (with approximately equal values at 0, 1 and 2 spots), a frequency not found on the small ones. What, may be enquired, is the meaning of such distinctions. In interpreting them we have to

remember that the spotting is stabilised at characteristic values on each island. This in itself excludes an explanation based on random genetic drift, so does the size of the various populations involved, for they may comprise thousands of imagines, ascertained by the technique of marking, release and recapture. We have indeed strong reasons for thinking that the butterflies are adjusted to the distinct ecology of each small Island but to the average of the conditions on the much more diversified large ones, and such averages tend to resemble one another (Ford, 1965).

It has also been suggested that the Founder principle operates here. Yet changes in these highly constant spotting types have actually been witnessed as the result of rare cataclysms. They have produced new and stabilised spot-frequencies differing as much from the old as those on one small Island differ from another.

We may consider the situation on White Island, which is divided into two parts, each about a quarter mile long, by a low narrow neck of land. This was covered by sand and shingle during a great storm in the winter of 1957–58. As a result, the *Maniola jurtina* population was subdivided. That on the southern half of the Island, previously stabilised with a mode at no spots, changed at once to a condition unimodal at one spot and remained for eleven years at the new frequency; until in 1969 the recently created barrier ceased to be effective owing to the growth of plants upon it and the spotting returned to its pre-1958 values. A selection-pressure of 68 per cent with 5 per cent confidence limits at 31–81 per cent, in favour of one-spotted individuals was needed to produce that result in 1958 (Creed *et al.*, 1964).

Turning briefly to *Maniola jurtina* as found in south-west England, the females there are bimodal at 0 and 2 spots, though in the rest of the country and throughout Continental Europe, except in its more peripheral regions, they are unimodal at 0 (Dowdeswell & McWhirter, 1967). Though the boundary between the two frequencies has repeatedly altered its position by several miles in a single generation of the butterfly, one type changes into the other in a few yards; it does so along a line crossing the peninsula of Devon from north to south. No physical boundary is involved and imagines of the respective stabilisations are constantly intermingling where they meet (Creed *et al.*, 1959).

In 1957 the boundary between the bimodal and unimodal types moved three miles eastward. This involved selection of 65 per cent, with 5 per cent, confidence limits of 31 to 82 per cent, against two-spotted individuals in the population involved. Such high selection-pressures now prove to be usual in the micro-evolution of the Lepidoptera, as we find them to be in other organisms.

In addition to selection, one of the features operating in evolution is provided by isolation, as Darwin clearly points out. An aspect of this, a curious one seldom considered, has just been mentioned: that provided by selection so powerful that it can break up a population into two adjusted types, maintained without geographical discontinuities, a situation sometimes manifested by the formation of a reverse cline (Ford, 1965), as indeed in *Maniola jurtina*. That is to say, the distinguishing characteristics of two populations become accentuated towards the line where they meet; selection being powerful enough to eliminate the less well adjusted intermediate types at the interface between them. Since, as we have seen, one spot-adjustment can be converted into another, there is no question of a past gap in the distribution of this insect from which populations with distinct spotting-types have spread until they have come into contact. That, of course, can occur and it produces somewhat similar results to the one just mentioned, though not the conversion of a part of one race into the other. Thus the Scandinavian and European races of the Selidosemid moth *Bupalus piniarius* L. meet and interbreed across England at the level of Lancashire and Cheshire (Cockayne, 1912–13). The one must be an Ice Age relict which has retreated northwards, the other a Holocene colonist from Europe. Yet their approximation has not produced a cline. On the contrary, there is an area of high variability between these differing adjacent populations, within which the recombinants are constantly produced though they fail to spread in either direction so as to swamp the characteristics and balanced adaptations of the two forms.

We have not indeed extensive information on the genetics of speciation and racial differences in the Lepidoptera. The distinctions between the *Bupalus piniarius* races appear to be multifactorial. Those separating closely related species may be also, or they may include characters resulting from the action of major genes.

The Lycaenid genus *Aricia* contains two European species not separated until 1935. These are the bivoltine *A. agestis* Schiff., the northern limit of which is reached in southern England and northern Denmark, and the univoltine *A. artaxerxes* F. from northern Britain, Norway, Sweden and Finland (Frydenberg and Høegh-Guldberg, 1966). Each includes a number of more or less distinct races and their characteristics must not be confused with those of the species as a whole. For instance, the features distinguishing *artaxerxes artaxerxes* from *artaxerxes salmacis* consist of a white central spot on the upper side of the forewings and an absence of the central black dot within the white spots on the lower surface. That condition is due to a single gene recessive in effect.

However, a number of characters, none in itself entirely distinctive, separate *A. agestis* and *A. artaxerxes*. These are quantitative only, yet some are unifactorial: thus one is provided by the more heavily marked larva of the latter species, another by the larger submarginal orange lunules on the upper side of the imagines (Høegh-Guldberg, 1968; Høegh-Guldberg and Jarvis, 1969). No feature is said to be fully diagnostic of these two butterflies except the double and single brooded habit. This is by no means a specific trait in other Lepidoptera; it is not so, for instance, in the moth *Zygaena lonicerae* v. Schev. (Lane and Rothschild, 1961). In *Aricia* that quality seems to depend on combined environmental and genetic influences, the latter multifactorial. Here, however, it does seem to some extent to separate two groups specifically, for crosses between them are to some extent infertile.

A rather similar situation from the evolutionary point of view is provided by *Pieris napi* L. and *P. bryoniae* Ochs. It is now said that their chromosome numbers differ: n = 25 in *napi* and 26 in *bryoniae* (Bowden, 1966*a*). *P. napi* is Holartic and occurs from sea-level up to high altitudes. *P. bryoniae* is alpine and boreal only, having a discontinuous distribution which includes parts of Scandinavia, the Alps, Central Asia and Canada. The two insects are separated by a number of features which tend to maintain their reproductive isolation: habitat, differences in time of flight, low viability of the hybrids and differential mating behaviour (Petersen, 1963). Their larval foods are not the same and though the males are very similar the females are highly distinct. *Bryoniae* differs from *napi* principally owing to the action of several major genes (Lorkovic, 1962): (1) *B*, which is autosomal and nearly dominant in effect spreading melanin along the veins, and (2) the gene *Y* which produces the ochreous-yellow ground-colour of *bryoniae*. It is incompletely dominant and is almost entirely sex-controlled to the females.

In addition, many populations of *bryoniae*, especially in the eastern Alps, are polymorphic for a gene *W* producing dominant white coloration on the underside of the hind wings and tips of the forewings (Bowden, 1963). This is allelic with that responsible for the two recessive yellow phases (*sulphurea*) found as rare recessive mutants in *P. napi*. It has been said that the polymorphism of this white-underside form (*subtalba*) is partly maintained by the lethality of the homozygotes. Bowden (1967) produced some evidence for this but certainly obtained homozygous whites. In this matter, a point of general importance must be recognised. That is to say, a selective disadvantage of 10 or 15 per cent may be effective in maintaining a polymorphism but very difficult to detect in experimental breeding.

It is especially to be noticed that both the genes *Y* and *W*, and probably *B*, occur as rare mutants in the normal population of *P. napi* (Bowden, 1963). We have here a clue to the extremely discontinuous distribution of *bryoniae*. That is to say, the genes capable of producing it are widely available when their action is appropriate to the ecology of this *Pieris* complex.

There are, of course, many instances in which a form controlled on a unifactorial basis appears to recur in isolation, though we do not know whether the same gene be responsible for it in the different habitats. Thus the Arctiid *Cycnia mendica* Cl. is ordinarily a sexually dimorphic species with black males and white females bearing black dots. In the Irish race, *rustica*, the males are white like the females, due to the action of a gene sex-controlled in effect and giving intermediate heterozygotes (Onslow, 1912; Ford, 1967a, plate 10). Yet *rustica* recurs in a few populations in Europe, or else its phenotype does so.

The moth *Triphaena comes* Hb., Caradrinidae, provides one of the few instances in which a phenomenon of this kind has been analysed from a comparative point of view. The dark form, *curtisii*, occurs as a polymorphism in three isolated populations: the Outer Hebrides, the Highlands of Scotland and in Orkney. It is identical in appearance in all of them. It has been shown that the Hebridean and Orcadean populations are due to the action of one major gene and that it is the same in both places, but it is adjusted by different modifiers to give an apparently identical effect in each (Ford, 1955). Here we really do know what is meant when we say that the "same" form of the species occurs in two distinct areas.

From this point we are, by an easy transition, taken over to another system of variation, that of polymorphism, and to another aspect of evolution, that of *Industrial Melanism.*

The Lepidoptera are, of course, famous for providing that outstanding reaction to pollution. Though known in other groups, (*e.g. Adalia bipunctata* L. among the Coleoptera, Coccinellidae), it is in the moths that Industrial Melanism is most widespread and striking (Kettlewell, 1957, 1961). This is not the place in which to discuss that situation, for it merits long and detailed attention, but a few of the facts relating to it can briefly be summarised.

Many dozens of species have become black in the industrial areas of Britain (where approximately 100 are affected), Continental Europe, the U.S.A. and elsewhere. Nearly all are controlled by a single major gene, dominant in effect. They spread owing to the action of two agencies. One is bird predation of the less cryptically coloured forms: the melanic insects on light coloured bark and lichens; and the normal pale ones on

trees, fences and other sites which are blackened by pollution in manufacturing districts. The second agency responsible for the spread of industrial melanics is the evolution of heterozygous advantage, which is brought about in either of two ways or by a combination of them: 1) the accumulation of common lethal or semi-lethal mutants close to the locus controlling the polymorphism; 2) the evolution of dominance, operating in different directions upon the multiple effects of the switch-gene. This causes the disadvantageous qualities it determines to become recessive and the advantageous ones dominant, so ensuring the superiority of the heterozygotes over the other two genotypes.

The occurrence of Industrial Melanism provides an exceptionally sensitive test for the spread of pollution outwards, and down the prevailing wind, from industrial areas. Moreover, we have here excellent examples of evolution in progress, for the melanic forms of many moths even though unifactorially controlled have become progressively better adjusted to their environments, both in their physiology and in their colouring, by selection operating on their gene-complexes (Kettlewell, 1965).

Only very rarely is an industrial melanic recessive. The large Bombycid *Lasiocampa quercus* L. provides an instance of the kind on a moor in Yorkshire. The area is heavily polluted with soot and a blackish-brown form of the moth occurs there (Kettlewell, 1959). Probably it is preferentially selected by the large numbers of Gulls which prey upon the species in that locality. The blackish specimens at present amount to only about 5 per cent of the population; though of course the gene responsible for them must occupy approximately 35 per cent of available loci, more if the heterozygotes are at an advantage.

An identical melanic is also found occupying up to 70 per cent of the population on heather moors in northeastern Scotland. There the plants are stunted and widely spaced, exposing the black peaty soil and giving the whole area a dark appearance. Here we return to the aspect of isolation that has just been discussed, for this is another of the rare instances in which it has been studied experimentally. The result proved that the two apparently similar blackish forms, in Yorkshire and north-east Scotland respectively, are generically distinct, being produced by different major genes. That in the Scottish population, moreover, is not fully recessive in effect.

In the Yorkshire population, where recessiveness is complete, an additional feature of interest is to be noticed. That is to say, a recessive black form of the larva also exists, which is absent from the Scotch locality. It is due to a separate gene from that giving rise to the dark imagines, but

the two loci are closely linked: in fact they are probably being built into a super-gene.

This indeed is characteristic of co-adapted genes when polymorphic. Selection tends to produce close linkage between them so that the appropriate features can segregate together. For polymorphism involves discontinuous variation, as in the human blood groups, in which even the rarer form is maintained selectively. The phases are indeed balanced either ecologically, as to some extent in butterfly mimicry, or by a superiority of the heterozygotes (Ford, 1965). Thus the evolution of supergenes, as of heterozygous advantage, will generally take place in polymorphism which must in view of these attributes be a very common phenomenon. It is, moreover, one which must nearly always be controlled genetically, by the segregation of a major gene or a super-gene. Environmental differences are indeed able to affect profoundly entire broods and populations, as in seasonal variation (which we see, for instance, in the Nymphaline butterfly *Araschnia levana* L.) (Ford, 1967*b*). They are hardly capable, however, of evoking discontinuous variability throughout a considerable region. This indeed becomes an impossibility when, as in polymorphic situations, the frequencies of the forms must be appropriately adjusted to differing ecological situations.

Polymorphism is usual in the Batesian mimicry of butterflies, in which its properties are clearly seen. For as the relative numbers of mimics sheltering under their resemblance to a distasteful form rises, so the benefit they obtain from doing so declines until it is lost and converted into a disadvantage. Therefore selection will favour the tendency for a Batesian mimic to copy several models. This it must do by means of polymorphism: evoking a mechanism, that is to say, which avoids intermediates and and therefore the production of unprotected forms.

Yet the switch-gene necessary to achieve this must have arisen by mutation, and we cannot expect its original effects to have been accurately adjusted so as to resemble a particular model. That is achieved gradually by selection, acting upon the gene-complex, within the ambit of the controlling major gene. Thus it is repeatedly found that mimicry even when "unifactorial" becomes imperfect in crosses with a race in which the appropriate model is absent (Clarke and Sheppard, 1960*a*).

The two major consequences of polymorphism are also exemplified in mimicry. The phases of a Batesian mimic often include non-mimetic forms which, as in normal polymorphic situations (the white and yellow females of *Colias*, for instance: Remington, 1954), are maintained by heterozygous advantage. This, and the selective adjustment involved, is demonstrated by the fact that mimics can sometimes exist even at high

frequencies outside the range of their models (as in the Polytrophus race of *Papilio dardanus* Brown, in the mountains east of Lake Victoria). That they do so demonstrates their physiological advantage; it demonstrates also the importance of their deceptive colour-patterns, for the accurate resemblance of these is lost in such circumstances (Clarke and Sheppard, 1960*b*).

The adjustments of mimicry are usually multiple, requiring the combined action of co-adapted genes. These must be held together in appropriate combinations by close linkage; their inappropriate ones, also produced, are eliminated by selection in the same way as are ordinary disadvantageous mutants. Clarke and Sheppard (1960*c*) have illustrated very clearly the evolution of such super-genes in mimicry. In this connection, their work on the Asiatic *Papilio memnon* L. is impressive (Clarke *et al.*, 1968). This species has numerous polymorphic female forms, some non-mimetic and some mimetic. Of the latter, one (*achates*), copies a tailed model (*Atrophaneura coon* F.), though the others do not, and it is accordingly provided with a tail. The gene responsible for this is included within the super-gene for colour-pattern so that it may operate in the necessary genetic setting, but not otherwise. However, the race of *P. memnon* inhabiting the Island of Palawan is exceptional, being invariably tailed, a condition also due to the action of a single gene. But this is not included within the super-gene controlling colour-pattern, for in this instance wing-shape is unassociated with mimicry.

An interesting discovery has lately been made which, in a sense, bridges the gap between the Batesian and Müllerian situations. In the latter, a number of inedible and warningly coloured butterflies, or other insects, shelter under a common colour-pattern, so that the lesson of distastefulness learned by a predator attacking one of them may apply to all. Brower, Brower & Corvino (1967), working on *Danaus plexippus* L., find that in this instance the objectionable substances present in the imago are derived from the larval food. When, however, as occasionally happens, such larvae eat non-poisonous plants, the resulting butterflies lack their normal protection and so shelter under the reputation of inedibility gained by the majority of the species, a situation which Brower *et al.* name *automimicry*. It may well involve many species in addition to *D. plexippus*.

Variation may be cryptic and, since as a gene spreads it will tend to generate heterozygous advantage and therefore become polymorphic, cryptic polymorphism must be widespread and important. Its existence is now being detected by means of electrophoresis, by which at least a

proportion of the protein-variability present in organisms can be recognised. Appropriate staining techniques can sometimes demonstrate all three genotypes controlling alternative esterases, and it has repeatedly been found that the heterozygotes are in excess of expectation, so establishing their superiority. Lewontin and Hubby (1966) who were pioneers in this work have indeed attempted to show that such protein diversity cannot be due to heterozygous advantage. They were lead to that view by the intrusion into their argument of two errors, well exposed by Milkman (1967). First, that the genes controlling distinct polymorphisms act independently. Yet as Milkman remarks, "artificial selection has taught us nothing if not the cumulative effect of genes at many loci." Secondly, Lewontin and Hubby hold that the unit of selection is the gene, whereas it is the individual. On the latter, and correct, basis Milkman develops a simple calculation which demonstrates the power of heterozygous advantage to maintain protein polymorphism.

Johnson and Burns (1966) using starch-gel electrophoresis found that the butterfly *Colias eurytheme* Bd. is subject to great protein (esterase) polymorphism, which differed both quantitatively and qualitatively in two populations from localities in Texas approximately 100 miles apart. Indeed, this technique has opened up a number of new possibilities in the analysis of adaptation and micro-evolution in general.

When in the 1920's I was envisaging the experimental study of evolution in wild populations, it seemed necessary to concentrate upon situations which promote rapid adaptation. Three of these proved highly satisfactory for that purpose but a fourth, the spread of species into new territories, was disappointing. I deduced that in the instances which happened to be available for study at the time, the adjustments which must surely be taking place were largely physiological. The technique of electrophoresis now provides an opportunity for testing that view. Numerous instances of species colonising new lands spring to mind. One may mention the Palaearctic *Pieris rapae* L., which has become one of the commonest butterflies in the U.S.A. since it was introduced there in the middle of the last century. Has it adjusted its protein variation to live in the New World? Electrophoresis will probably provide an answer to that question.

A somewhat exceptional type of polymorphism occurs in a single population of the moth *Panaxia dominula* L., Hypsidae (Ford & Sheppard, 1969). Its study has produced results which call for some comment. The species has one generation in the year and is widespread in Continental Europe and southern England; occurring in marshes and along river banks, where

the larvae feed chiefly upon *Symphytum*. The polymorphism occurs naturally in a single locality only, one of 17 acres in Berkshire. This has certain peculiar features of soil and ecology which may account for the exceptional characteristics of the moth there.

Its polymorphism is controlled by a pair of alleles in which all three genotypes are distinct. It is therefore possible to calculate gene-frequency by inspection, which has so far been done yearly from 1939 to 1970. Moreover, the numbers in the colony have been assessed by the technique of marking, release and recapture from 1941 onwards. It is possible to determine how fast a gene can spread if both its frequency and the size of the population in which it occurs be known. In this instance, for the first time, both these requirements were met. The annual fluctuation in the ratio of the alleles proved to be too great to be the result of random processes, such as genetic drift, and must be due to selection changing sometimes in frequency and direction.

In this instance, the polymorphism is not controlled by heterozygous advantage; indeed there is a clear indication that there has not yet been time for this to evolve in the community. The diversity is, in fact, maintained by assortative mating, for the females favour pairing with males of either of the two phases to which they do not belong.

The heterozygotes are somewhat variable. Indeed it proved possible by only four generations of selection in the laboratory on the one hand significantly to increase and on the other to diminish their expression, in the sense of departure from the normal homozygous type: that is to say, changing the terminology, to make them respectively more dominant or more recessive.

In 1954 the polymorphism was started artificially by P. M. Sheppard in another isolated colony a mile away. It is now found that changes similar in type to those produced in the laboratory, but taking place much more slowly, are occurring in these two wild communities. The expression of the gene is becoming more dominant in the marsh where it occurred naturally and more recessive in the one where it was introduced. This is perhaps the first time that it has been possible to forestall experimentally an evolutionary change that has occurred subsequently in nature.

The most importance outcome of using the Lepidoptera in scientific research, as indeed in applying the techniques of ecological genetics to organisms in general, is surely the discovery that natural selection is much more powerful than had previously been realised. We had been accustomed to think of a selection-pressure of 1 per cent in favour of advantageous qualities in nature as high. Today we realise that it frequently reaches 40 or 60 per cent. Here we must notice that these values

are often balanced in equilibrium, so that the overall selective advantage or disadvantage may indeed be small. Yet the powerful components involved facilitate rapid adjustments to changing conditions, a situation which alters fundamentally our concepts of micro-evolution.

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FERGUSON COLLECTION TO SMITHSONIAN INSTITUTION

Dr. Douglas C. Ferguson, formerly of the Nova Scotia Museum and Yale University, recently assumed a position as specialist on Geometroidea and Pyraloidea with the United States Department of Agriculture at the National Museum of Natural History. Shortly after joining the staff, Dr. Ferguson presented to the Smithsonian Institution his excellent collection of Lepidoptera. Over 51,000 insects are contained in this collection, of which nearly 48,000 specimens are Lepidoptera. Dr. Ferguson's donation represents over 23 years of concentrated collecting, conducted for the most part in the Atlantic Provinces of Canada. Nearly all major families of Lepidoptera are represented, and the total coverage of 3,000 species from an area previously not well documented in the collections of the National Museum is particularly noteworthy. The collection is extremely rich in Noctuoidea and Geometroidea, containing approximately 38,000 beautifully prepared specimens of those groups. Over 150 species of identified lepidopterous larvae, associated with reared adults, are also included. Although no holotypes are present in the collection, about 300 paratypes of 50 species are, as well as many undescribed species.

The addition of this generous gift has significantly improved the overall representation of North American Lepidoptera at the Smithsonian Institution.

DONALD RAY DAVIS, *Curator, Department of Entomology, Smithsonian Institution, Washington, D.C.*

NEW SPECIES OF AFRICAN GEOMETRINAE (GEOMETRIDAE)

R. H. Carcasson
Centennial Museum, Vancouver, B.C.

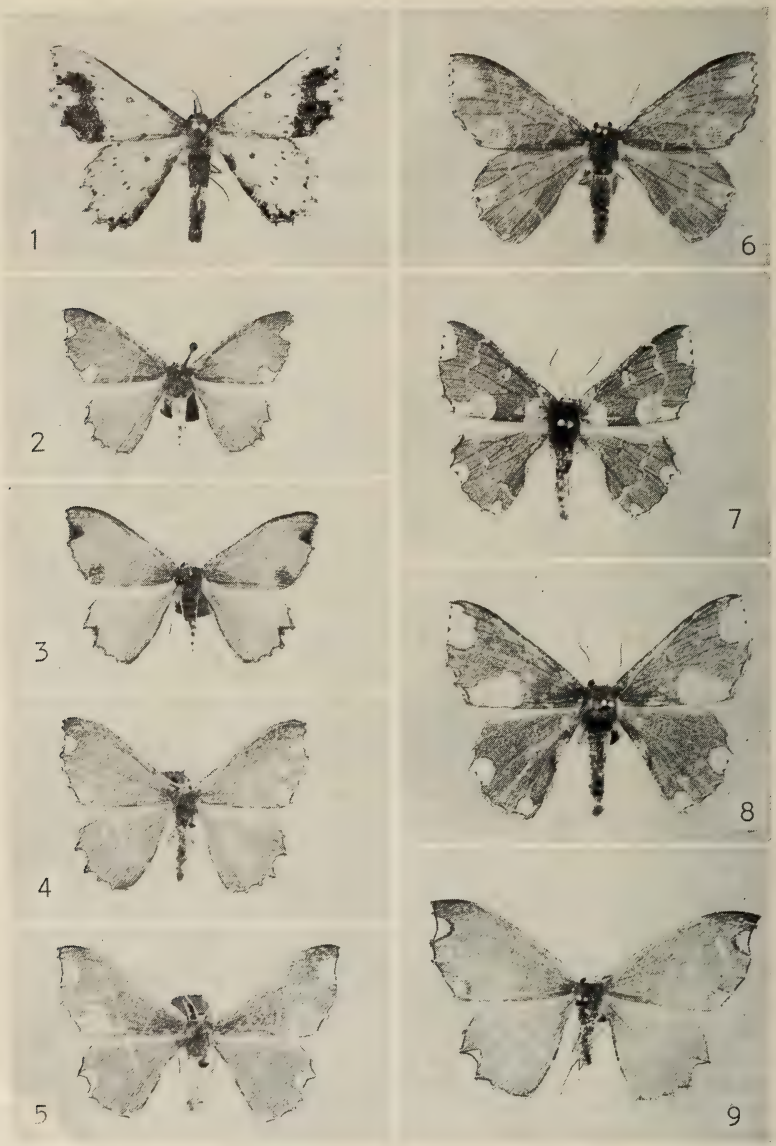
Victoria watsonae Carcasson, **new species**

Figs. 1, 14

Allied to *V. melanochlora* Carcasson (1962: 54) and to *V. gordoni* Prout (1912: 86), but differs from both in having the edges of the black markings diffuse, not well defined and in having no densely scaled green areas.

MALE. *Antennae*: Basal half pectinated, distal half simple. Dorsal aspect of shaft covered by pale pinkish brown (5YR 8/4 Munsell) white and sepia scales. *Head*: Vertex pinkish brown speckled with sepia. Frons whitish. Palpi cinnamon with sepia scales, laterally fringed with white below. *Thorax*: Patagia and tegulae light blue green (10G 7/4 Munsell). Dorsum anteriorly and laterally light blue green, reddish speckled with sepia at base. Venter whitish except for a vinaceous light red anterior collar. Inner surface of legs whitish, outer surface of tibiae and tarsi cinnamon speckled with sepia. *Abdomen*: Above pinkish white, 3 anterior segments heavily speckled with sepia and cinnamon. Segments 2 and 3 with a prominent dorsal crest consisting of very long, curly, pinkish cinnamon and sepia scales. Similar crests on 4, 5 and 6, but much paler, laterally edged with sepia. The crest on 6 just a small white tuft. Underside creamy white. *Upperside of forewing*: 17 mm from base to apex. Apex rather acute, termen regularly indented between veins. Wing lightly scaled, ground colour light blue green (10G 7/4 Munsell) with a few scattered blackish scales. Costa brownish pink speckled with sepia. Stigma a ring of raised blackish scales. Antemedial irregular, reduced to a blackish spot near costa, a faint blackish spot at cubitus and another at inner margin, connected by irregularly scattered blackish scales. Postmedial roughly parallel to outer margin, consisting of small irregular blackish dots at the veins from costa at 4/5 from base to inner margin at 2/3 from base. A large blackish blotch with diffuse margins containing scattered pinkish scales between postmedial and termen, from vein 6 to tornus and inner margin, reaching termen except between veins 3 and 4 where it encloses a large green marginal spot. A black terminal dot in space 3 and smaller one in space 6. Fringe blackish where dark areas reach the margin, otherwise pinkish mixed with blackish and green scales. *Hind wing*: Margin with deep inter-nervular indentations. Ends of veins 2, 3, 4 and 6 especially produced. Ground colour as in fw. A small patch of dense, silky white scales at base. Stigma a densely scaled black dot surmounted by a smaller orange pink dot. Postmedial irregular, consisting of small ill-defined blackish dots at the veins. Inner margin blackish with a few pink scales, except at base which is green. Tornus and termen up to vein 3 blackish. A blackish dot in space 2 near termen. A small black terminal spot in space 3, a larger one in 4, some black scales at termen of space 6 and at apex. Fringe as in fw. but with more green in pale areas. *Underside*: Thinly scaled, opalescent white, with dark stigmas, marginal spots and postmedial faintly showing through from upper surface. Blackish fw blotch as above, but denser, lacking pink scales.

Genitalia: Uncus sharply pointed, only slightly downcurved forming a rough equilateral triangle; a small rounded heavily sclerotised plate, almost at centre of uncus. Subunci membranous, hairy, not reaching tip of uncus. Gnathos a stout pointed process directed ventrad attached to a strong, heart-shaped sclerotised ring. Saccus short and pointed. Valve long and narrow, spatulate, terminating in a dorso-apical lobe densely covered internally by long, stout peg-like projections. Harpe long, narrow, sharply pointed, protruding beyond apex of valve. Aedeagus short and stout, lightly sclerotised, with long longitudinal apical opening on left side. Vesica protruding from



Figs. 1–9. African Geometrinae. 1, *Victoria watsonae* sp. nov., ♂; 2, *Archichlora rectilineata* sp. nov., ♂, holotype; 3, same, ♂, paratype (dark form, Mufindi); 4, same ♂ (Kigezi, Uganda); 5, same ♀, allotype; 6, *Archichlora sangoana* sp. nov., ♂, paratype; 7, *Archichlora jacksoni* sp. nov., ♂, holotype; 8, *Archichlora pulveriplaga* (Warren), ♂ (Kalinzu forest, Ankole, Uganda); 9, *Archichlora rectilineata* sp. nov., ♀ (Njoro, Kenya.)

All specimens reproduced at natural size.

left side of aedeagus, armed with two very large curved blunt spines, the apical larger and directed to the right, the smaller arising well below the apical and curving towards the left when not extruded.

Holotype. ♂, Grassfield, Nimba, Liberia, VI-VII 1967, Mrs. A. Forbes-Watson, to be deposited in the British Museum (Natural History). *Paratypes*: 4♂♂, data as above; 1, VI-VII 1967, 1 VII-VIII 1967, 1 II 1968, 1 VIII-IX 1967, to be deposited in National Museum, Nairobi, Kenya.

Archichlora jacksoni Carcasson, **new species**

Figs. 7, 10

Allied to *A. pulveriplaga* (Warren), (1898: 14), (figs. 8, 12), but differs in its smaller size, continuous pinkish postmedial line and in the presence of a basal pinkish blotch in the forewing.

MALE. *Antennae*: Basal half armed with short stiff pectinations. Proximal portion of shaft covered dorsally by white and light carmine scales, remainder light carmine. *Head*: Vertex white with a transverse carmine band mixed with sepia scales. Frons bright yellow green (10GY 6/6 Munsell). Palpi vinaceous red laterally, white ventrally. *Thorax*: Above bright yellow green (10GY 6/6 Munsell), shading to brownish red at posterior margin, uniform creamy white below. *Legs*: fore and mid legs white, speckled with carmine and vinaceous red on external surfaces; hind legs white. *Abdomen*: dorsal surface creamy white densely speckled with bright pink and sepia scales. Segments 2, 3, 4 and 5 armed with prominent pink and white, laterally sepia crests. Lateral and anal tufts creamy white. Venter creamy white. *Upperside of forewing*: 13–18 mm from base to apex. Costa very slightly incurved near middle, apex acute, but not falcate, outer margin slightly crenulate. Ground colour bright yellow green (10GY 6/6 Munsell). Costa broadly white, densely speckled with bright pink and sepia. An oval green spot at base of radius enclosed by an irregular whitish basal area speckled with sepia and pink particularly at base and inner margin. Pale basal area limited distally by narrow blackish antemedial and by some red scales. Ante medial starts at costa at 1/7 from base, bends sharply proximad in base of cell, curves regularly between cubitus and 1a, reaching inner margin at 1/4 from base. Stigma reniform, very large, pale pink surrounded by a narrow dark ring, enclosing irregular dark centre. Postdiscal very clearly defined, pale pink, narrowly edged on both sides with mixed blackish and red scales, from costa at 3/4 from base, angled distad at veins 7 and 6, broadening and bulging proximad from 6 to 4 narrowing and forming a broad, even curve distad to centre of space 2 where it becomes the inner margin of a large irregular pale tornal blotch. Tornal spot pale pink, narrowly edged with blackish and red scales, enclosing some red, brown and green scales; proximal margin of tornal spot (postmedial) curves abruptly proximad in space 1b reaching inner margin at just over 1/2 from base. Distally edge of tornal spot is angled distad at vein 2, then dips below it reaching termen at end of vein 2. A large pinkish white marginal spot with irregularly crenulate proximal margin edged with blackish and red scales, from apex to vein 3. Two small pinkish terminal lunules edged proximally with blackish and red in spaces 2 and 3. Termen narrowly sepia, broadening into small dark spots in spaces 4, 5, 6 and 7. Fringe whitish, mixed with some red and blackish, particularly at end of veins. *Hind wing*: Outer margin regularly crenulated. End of vein 6 especially produced. Ground colour as in fw, but costal area broadly white. Some bright red scales at base and separating white costal area from remaining green area. An elongated pinkish inner marginal area edged with blackish from base to middle of inner margin. Stigma narrower than in fw and more densely obscured by dark scales. Postmedial as in fw, of irregular thickness and shape but maintaining approximately same distance from margin throughout. A very large black-edged pinkish lunule in spaces 4–5 and a smaller one at tornus. A narrow blackish terminal

line wider at middle of internervular spaces. Fringe as in fw. *Underside*: Very pale green almost white with markings of upperside showing as pure white and faint red terminal line widening into minute lunules between the veins.

Genitalia: Uncus short, pointed, slightly downcurved, base 2/3 of length with a prominent lateral notch at each side. Subunci slender, membranous, hairy, shorter than uncus. Gnathos directed ventrad, slightly constricted at base, terminating in an anteroposteriorly flattened, bluntly pointed lobe armed with minute tubercles on posterior surface. Saccus short, broad and almost truncated apically. Valve regular, long and narrow, bluntly pointed apically. Harpe long and narrow, smooth, bluntly pointed apically and curving inward with dorsal margin almost parallel to costa of valve, somewhat shorter than valve. *Aedeagus*: basal half long and much narrower than remainder which is more lightly sclerotised except laterally and compressed into numerous minute folds. Apical opening long, longitudinal, on ventral surface, armed at base on left side by a blunt reflexed sclerotised lobe.

Holotype. ♂, Kakamega, Kenya, XII 1966, R. H. Carcasson and A. Forbes -Watson, to be deposited in British Museum (Natural History). *Paratypes*: ♂, Kakamega Kenya XI 1967, R. H. Carcasson, to be deposited in British Museum (Natural History); ♂, all data as above, to be deposited in National Museum, Nairobi; ♂, locality as above, III–1966, R. H. Carcasson, to be deposited in National Museum, Nairobi; ♂, Mt. Elgon, Kenya, VII–1966, T. H. E. Jackson, to be deposited in National Museum, Nairobi.

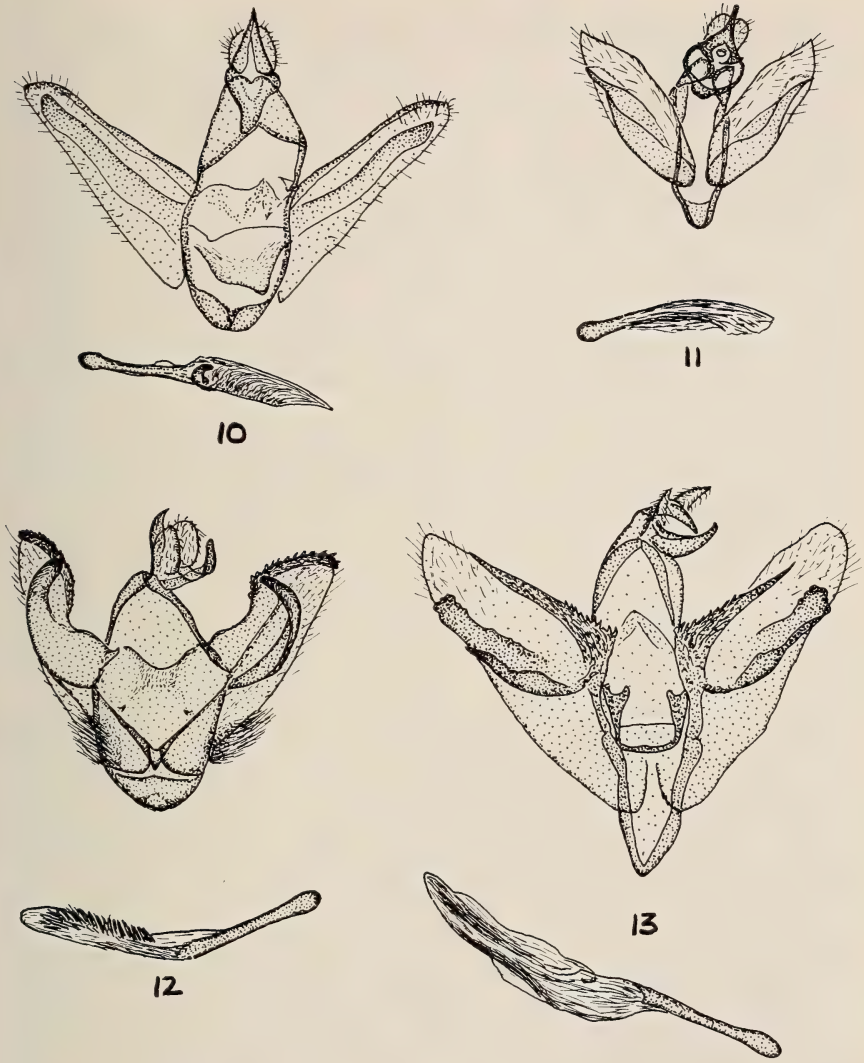
This species is dedicated to my friend, the late Mr. T. H. E. Jackson of Kitale, Kenya.

Archichlora sangoana Carcasson, **new species**

Figs. 6, 13

Closely allied to *A. pulveriplaga* (Warren), (Figs. 8, 12), but differs in having continuous, sinuous postmedial lines and smaller terminal blotches.

MALE. *Antennae*: Basal pectinations decreasing very gradually from base to apex. Dorsal aspect of basal third of shaft covered by white scales. *Head*: Vertex white with a reddish dot at base of each antenna and a reddish basal tuft at each side. Frons bright green with some reddish scales at superior margin. Palpi whitish below, light orange brown above. A fringe of reddish hair-scales at lower margin of eye. *Thorax*: Uniform bright green above, except last segment which is light brown dorsally, yellowish laterally. Ventral surface of thorax woolly, pale green anteriorly, white laterally and posteriorly. *Legs*: Orange brown externally, creamy white internally. *Abdomen*: 1st segment light brown with a small paler dorsal tuft. Subsequent segments very pale brown with a dark dot flanking each side of the pale dorsal tufts. Underside uniform creamy white. *Upperside of forewing*: 17–20 mm from base to apex. Costa very slightly concave near middle, evenly convex at 3/4 from base. Apex acute. Termen moderately crenulate, tornus blunt. Ground colour green (25G 6/8 Munsell). Costa creamy white, mixed with purplish and red scales at base. A narrow blackish line separating white of costa from green ground colour near apex. Antemedial narrow, greenish yellow, from costa at 1/6 from base, to inner margin at 1/3 from base, slightly angled distad at cubitus and at 1b. Postmedial narrow, greenish yellow, from costa at 3/4 from base to inner margin at 2/3 from base, evenly and slightly curved distad from costa to vein 3, more strongly curved proximad from vein 3 to inner margin. Stigma large, pinkish white, surrounded by a ring of mixed blackish and red scales with a central dot of the same colour. A large whitish terminal blotch from vein 7 almost to vein 4, the proximal edge of which projects proximad in space 6 and more strongly so along vein 5. The pale blotch enclosing some bright ochreous scales and a few blackish scales in spaces 5 and 4, and narrowly edged proximally by a mixture of blackish and red scales. A similar but more rounded whitish blotch at tornus, in



Figs. 10–13. Male genitalia of African Geometrinae. 10, *Archichlora jacksoni* sp. nov., paratype; 11, *Archichlora rectilineata* sp. nov., paratype (Nairobi, Kenya); 12, *Archichlora pulveriplaga* (Warren), (Kalinzu forest, Uganda); 13, *Archichlora sangoana* sp. nov., paratype.

spaces 1a, 1b and 2, with a narrow terminal extension in space 2. Termen narrowly blackish, forming small internervular lunules in the areas occupied by the pale blotches. Cilia whitish, chequered with blackish at the ends of the veins. *Hind wing*: Outer margin somewhat produced at vein 6 and slightly concave between 6 and 4. Ground colour as above. Postmedial as above, parallel to outer margin. Stigma very small. A marginal blotch similar to those of fw but smaller and more regular between veins

6 and 4. A very small whitish blotch at tornus, joined to a similar small triangle pointed proximad along vein 1b, both edged with blackish and red scales. A small white patch at base. Inner margin narrowly edged with pinkish, blackish and red scales and hairs. Termen as in fw. Cilia uniformly grey, tipped with pinkish. *Underside*: Uniformly white, with markings of upperside showing through very faintly. Termen and cilia very narrowly blackish.

Genitalia: Uncus short, pointed, downcurved, almost as wide basally as long. Subunci short, membranous, hairy, pointed, projecting laterad and posterad, almost as long as uncus. Gnathos stout, pointed, projecting backwards, almost as long as uncus, its inner (posterior) surface serrated. Saccus short, broad and blunt. Valve apically pointed, tapering rapidly from a very broad base. Harpe broad, long, curved inwards, irregularly shaped, with irregularly jagged margin, shorter than valve. A long sharply pointed process projecting backwards from dorsal part of base of valve, armed dorsally and on internal face with numerous sharp appressed teeth. Aedeagus long, basal half much narrower than remainder, terminating in a pronounced rounded bulb-like expansion. Apical half membranous, compressed into numerous small longitudinal folds, unarmed. Opening long, ventral, longitudinal.

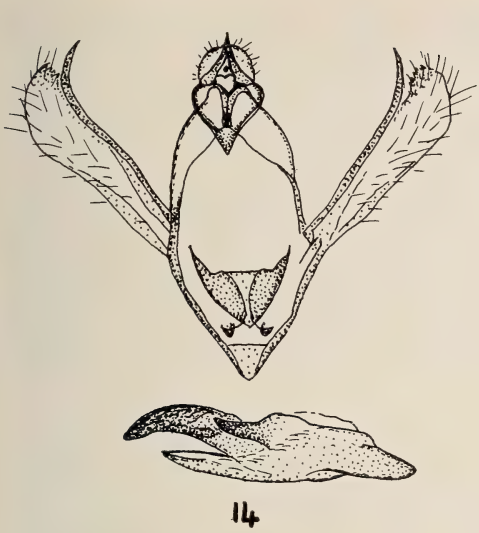
Holotype. ♂, Katera, Sango Bay, Masaka, Uganda. X-1960, R. H. Carcasson. *Paratypes*: 9♂♂, Malabigambo forest, Sango Bay, Uganda, II-1968, A. L. Archer. Holotype and 4 paratypes to be deposited in British Museum (Natural History); remaining 5 paratypes to be deposited in National Museum, Nairobi.

Archichlora rectilineata Carcasson, **new species**

Figs. 2, 3, 4, 5, 9, 11, 15

Superficially similar to *A. pulveriplaga* (Warren), (Figs. 8, 12), and to *A. sangoana* Carcasson (Figs. 6, 13), but differs from both in being smaller, more slenderly built and in having straight postmedial lines.

MALE. *Antennae*: Basal half of shaft decorated dorsally with white, black and red scales. *Head*: Vertex white, sprinkled with red and black scales. Frons bright green, palpi creamy, speckled dorsally and especially apically with rusty brown. *Thorax*: Bright green (10GY 5/6 Munsell) dorsally. Very pale green below, shading to creamy white posteriorly. *Legs*: Very pale creamy buff, forelegs spotted with dark brown on exterior surface. *Abdomen*: Above: 1st segment purplish brown, remaining segments creamy buff, creamy white from segment 6 to apex. A pinkish dorsal crest on first 4 segments. A dark brown dorsal spot on segments 5, 6 and 7. Below: uniformly creamy white. *Upperside of forewing*: 15–16 mm from base to apex. Costa slightly but evenly arched. Apex acute. Outer margin slightly sinuous. Ends of veins 3, 4 and 7 slightly produced. Outer margin slightly concave from vein 4 to vein 7. Ground colour bright green (10GY 5/6 Munsell) with very faint paler vermiculations. Costa whitish, densely speckled with blackish and red scales. A small patch of such scales at base of costa. Antemedial narrow, light yellow-green, evenly curved from costa at 1/5 from base to inner margin at 2/5 from base. Postmedial slightly wavy, narrow, light yellow green, from costa at 3/4 from base to inner margin at 2/3 from base. Stigma a small whitish dot edged with blackish and red scales. A very pale pinkish, somewhat irregular, marginal lunule from just above vein 4 to middle of space 6, edged proximally by a very narrow blackish line. A similar but larger rounded blotch at tornus enclosing an area speckled with dark scales. Terminal line blackish, very narrow, of uniform width. Cilia whitish mixed with pink, blackish at the veins. *Hind wing*: Margin deeply crenulate, veins 6 and 4 especially produced. Ground colour as above. Postmedial as above, almost straight from just above junction of veins 6 and 7 to inner margin just beyond 2/3 from base. Stigma very small, white. A whitish marginal lunule similar to that of fw with its apex directed proximad along vein 5. A similar but much smaller spot at tornus. Terminal line as in fw, cilia somewhat darker. Inner margin narrowly edged with blackish and red scales and by long





Figs. 14, 15. Male and female genitalia of African Geometrinae. 14, *Victoria watsonae* sp. nov., ♂, paratype; 15, *Archichlora rectilineata* sp. nov., ♀, paratype.

whitish hairs. *Underside*: Generally whitish, shading to light green at costa and apex of fw. Costa of fw narrowly blackish, stigma a minute reddish dot barely visible in hw. Lunule of fw sepia, if present, with ill defined proximal edge. Terminal line and cilia of both wings as above.

Genitalia: Genital capsule slender and lightly sclerotised. Uncus short, downcurved and sharply pointed. Subunci broad, membranous, hairy, almost as long as uncus. Gnathos a simple, bluntly pointed short projection. Saccus short, apically rounded. Valve simple, regular, with apex gently pointed, rather broad at base, and with ventral margin strongly elbowed midway from tip of saccus to apex. Harpe simple, broad, close to ventral margin of valve, terminating in a smooth, inwardly curving spoon-like lobe, apex of harpe not reaching apex of valve. Aedeagus lightly sclerotised, unarmed, with basal bulb much shorter and broader than in other species. Opening of aedeagus long, ventral.

FEMALE. Similar to male, but larger, with more rounded wings. Fw 18–20 mm from base to apex. Ovipositor lobes long and slender, curving inwards near apex. Anterior and posterior struts slender and moderately long. Ostium simple, opening posterad, vaginal plates very weakly sclerotised. Colliculum absent, ductus long and slender with a sack-like expansion near base. Bursa long and slender, ovoid. Signum at base of bursa, a smooth, large, irregularly rounded sclerotised plate with an inward projecting, straight, transverse median ridge.

Two males from Mufindi, Iringa, Tanzania, belong to an individual melanistic variant in which the dorsum of the abdomen is much darker, the marginal lunules and blotches are completely filled in by blackish scales and the cilia are uniformly blackish. A male from Kigezi, Western Uganda, and a female from Njoro, Kenya are identical, with typical form, but have a slightly curved postmedial in the hw and may represent a West Rift subspecies.

Holotype. ♂ (pale form), Mufindi, Iringa, Tanzania, P. Burdon, to be deposited in British Museum (Natural History); *Allotype*: ♀ (pale form), Amani, Usambara, Tanzania, X-1962, G. Pringle (No P 1188); *Paratypes*: ♂ (pale form), Ngong, Nairobi, Kenya, II-1954, Fowler and Coulson, in National Museum, Nairobi; ♂ (dark form) Mufindi, Iringa, Tanzania, 1955, P. Burdon, to be deposited in British Museum (Natural History); ♂ (dark form), data as above, in National Museum, Nairobi; ♀ (pale form) Nairobi, Kenya, VI-1958, R. Carcasson, in National Museum, Nairobi.

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BOOK REVIEW

A KEY TO THE RHOPALOCERA BUTTERFLIES OF WYOMING, by Clifford D. Ferris. Science Monograph No. 21, Agriculture Experiment Station, University of Wyoming, Laramie, Wyo. January 1971. 64 pp., 3 figs., 8 pls.

Dr. Ferris has tried to present in this slim volume a useable key to the butterflies of Wyoming. Like all keys that I have seen, it is useful in the hands of those of us who need no key and not so in the hands of a rank amateur. The eight plates at the back of the book figure in black-and-white all of the species that the 4-H member or beginner will find. The key to *Colias* and the discussions of *Speyeria* and *Euphydryas* will be found helpful to those who have Wyoming material to name. An annotated checklist for the state is promised for "late 1971." From what I have seen of Ferris's notes for this it is going to be a most useful index to the species found and where they usually may be caught. Dr. Ferris did not see final page proof, so, there are a few typographical errors that he would have caught.

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THE LIFE HISTORY OF *SCHINIA SEPARATA* (NOCTUIDAE)

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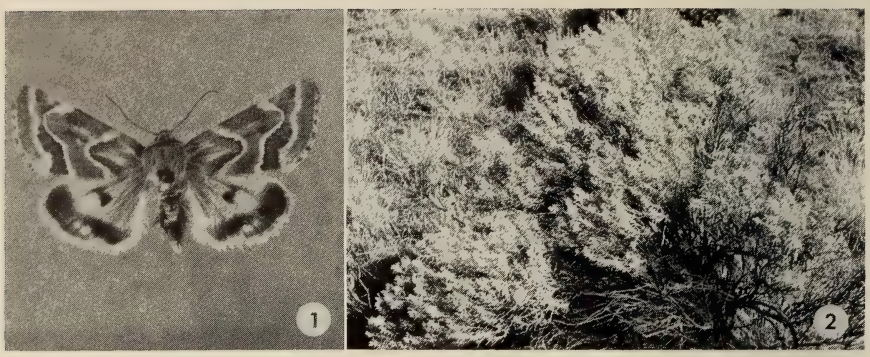
Schinia separata (Grote, 1879)[1] is distributed in western North America from southern British Columbia and Alberta southward to southern California. In the Intermountain Basin area, it feeds in the larval stage on the buds and blossoms of the sagebrush, *Artemisia tridentata* Nutt. (Figure 2). The moth is also common in some areas of the Great Plains in which sagebrush does not occur but in which the hoary sagebush, *Artemisia cana* Pursh. is abundant. Presumably in these grassland areas, the latter species of *Artemisia* serves as food plant. The adult is a late-summer flier and is present in most areas of its range during August and the first half of September. In the Intermountain Basin the period of adult activity is synchronized with the budding period of the sagebrush and the moth flies progressively later in the season with decreasing altitude and latitude.

Behaviour

Schinia separata is a nocturnal species, and the eggs are deposited in the buds of *Artemisia* only at night. Three wild-caught females deposited a mean of 91 eggs and the maximum deposited by a single female was 119. The behaviour of the ovipositing female *separata* was described in my 1958 revision of the elliptoid-eyed *Schinia*:

"The female alights on a spray of the still tightly closed buds and crawls over it, her abdomen arching ventrally. Having arrived at a site that is apparently suitable, she secures herself by grasping buds and stems firmly with clawed tarsi, and begins an elaborate exploration with the ovipositor. The abdomen is arched ventrally and anteriorly, often being thrust forward so as to protrude through the legs. The ovipositor, on encountering the small hard bud, feels the surface and probes it with short, delicate stabbing movements. When the edge of one of the stiff outer sepals of the bud is encountered the blade of the knife-like ovipositor is forced against this edge and the moth, by rapid lateral movements of the abdomen which cause her whole body to vibrate inserts the ovipositor valves beneath the sepal. In this manner the egg is deposited within the bud at or between the bases of the innermost sepals. The ovipositor is then withdrawn and the moth usually flies to another bud cluster before the process is repeated."

[1] I cannot distinguish *separata* from *Schinia acutilinea* (Grt.) (1878, Can. Ent. 10: 232) with any degree of certainty, but hesitate to synonymize the two without fuller study. If the two names do represent the same species, *acutilinea* will take precedence.



Figs. 1, 2. *Schinia separata* (Grt.) and its food plant. 1, Adult, Oliver, B. C.; 2, *Artemisia tridentata* Nutt.

The egg is often grossly distorted in shape as a result of being inserted beneath the sepals among the developing petals of the still tightly closed bud. The majority of eggs hatch on the seventh day after deposition. The newly hatched larva immediately attacks the succulent tissues of the developing bud. The larva usually completes its first stadium in the initial bud, but during the second stadium migrates to an adjacent bud which it enters by boring a hole through the apex where the sepals are thinnest. The anterior two pairs of larval prolegs are reduced in size in the second and third instars and the larva mixed with a looping motion similar to that of catocaline larvae. During the third stadium the larva ceases to conceal itself completely within the bud and feeds from an exposed position on the stem. The larvae continue to attack the buds at the apex, however, where the tissues are softer.

Nineteen of 50 individually reared larvae matured in five stadia, the remainder in six. The mature larva tunnels into the ground to form its pupal cell and it is in the pupal stage that the insect remains throughout the majority of the year.

Descriptions of Stages

The following descriptions of immature stages were based on the progeny of three females taken in the Okanagan Valley near Oliver, B. C. The larvae were reared individually at room temperature on the buds and blossoms of *Artemisia tridentata*. Rearing techniques employed were those used by Hardwick (1958). The estimate of variability following the mean for various values is the standard deviation.

Unfortunately the larvae of *separata* being reared had to be removed from the Okanagan Valley to Ottawa during the median stadia. Although flowering heads of the food plant were shipped by air express to Ottawa,

the larvae did not develop normally and the ultimate stadium became greatly protracted. The larvae eventually died without pupating. The developmental data is therefore not complete, and the durations listed for the median stadia may be somewhat attenuated.

Adult. (Fig. 1). Head and thorax silvery-fawn to greyish-fawn. Abdomen silvery-fawn or silvery-grey. Underside of body dull pale grey. *Forewing* olivaceous fawn marked with white; forewing occasionally with a rosy suffusion. Transverse anterior line white, usually smooth, arched strongly and acutely outward. Basal space olivaceous fawn, longitudinally streaked with white and with a dark margin along t.a. line. Transverse posterior line white, generally smooth, excurved around cell, then usually straight to inner margin. Median space fawn, paler than basal space, usually with a pale longitudinal streak through cell. Orbicular spot not defined. Reniform spot usually indicated only as a narrow dark shade. Subterminal line white, irregular, closely approaching and occasionally fusing with outward arc of t.p. line. Subterminal space darker than median space and usually darker than basal space. Terminal space pale fawn. Fringe white checkered with fawn. *Hind wing* white with dark-brown discal mark and dark-brown outer-marginal band. Outer-marginal band with a white streak or blotch toward anal angle. Fringe white, usually with a pallid brown inner line. *Undersides* of both wings white or pallid grey, marked with brown. Forewing with small, dark-brown, orbicular and reniform spots, and with a paler brown subterminal band. Hind wing with a narrow dark-brown discal spot and an evanescent outer-subterminal band. Fringes of both wings white.

Expanse: 26.4 ± 2.2 mm (92 specimens).

Egg. Very pale greenish-yellow when deposited. Losing some of greenish colouring on the second day, then remaining essentially unchanged for remainder of incubation period. Mandibles and ocelli becoming visible through chorion a few hours before hatching.

Incubation period: 7.2 ± 0.7 days (157 eggs).

First-Stadium Larva. Head translucent blackish-grey. Prothoracic and suranal shields somewhat paler than head. Trunk pale greyish-white becoming stained with yellow or green after larva begins to feed. Thoracic legs and proleg shields dark smoky-brown.

Head width: 0.240 ± 0.011 mm (25 larvae).

Duration of stadium: larvae maturing in five stadia, 5.3 ± 0.7 days (19 larvae); larvae maturing in six stadia, 5.1 ± 0.4 days (31 larvae).

Second-Stadium Larva. Head varying from dark brown to medium light brown. Prothoracic shield concolorous with trunk except for some pale-brown flecking. Suranal shield concolorous with trunk. Trunk with a chalky opacity uncommon in second-stadium noctuid larvae; varying from a blotchy yellowish-grey to a blotchy greenish-grey. Thoracic legs and proleg shields brown. First two pairs of anal prolegs smaller than remaining pairs.

Head width: 0.319 ± 0.010 mm (25 larvae).

Duration of stadium: larvae maturing in five stadia, 4.0 ± 0.6 days (19 larvae); larvae maturing in six stadia, 4.1 ± 0.6 days (31 larvae).

Third-Stadium Larva. Head pale fawn grey. Prothoracic shield whitish-grey marked with brown. Suranal shield essentially undistinguished from trunk. Mid-dorsal area dull, dark brownish-grey. Subdorsal area white or pale grey with a pair of dark-grey median lines. Supraspiracular area dark greyish-brown, with a discontinuous, white or pale-grey median line. Spiracular band white or pale grey with a darker-grey or brown median shade. Suprapodal area similar in colour to supraspiracular area. Mid-ventral area varying from greenish-grey to brownish-yellow.

Head width: 0.51 ± 0.02 mm (25 larvae).

Duration of stadium: larvae maturing in five stadia, 6.1 ± 1.2 days (19 larvae); larvae maturing in six stadia, 4.9 ± 1.1 days (31 larvae).

Antepenultimate-Fourth-Stadium Larva. Head fawn-grey heavily marked with medium brown. Prothoracic shield white, usually heavily suffused with brown; heavily suffused shields with three well-defined longitudinal white lines. Suranal shield concolorous with trunk. Mid-dorsal band dark-brown with a pale median shade. Subdorsal area pale grey or white with a pair of pale-brown median lines. Supraspiracular area brown with a badly broken white or pale-grey median line. Spiracular band white with an irregular light-brown median line. Suprapodal area concolorous with supraspiracular area. Mid-ventral area pale grey mottled with light brown.

Head width: 0.74 ± 0.03 mm (44 larvae).

Duration of stadium: 5.7 ± 1.1 days (31 larvae).

Penultimate-Stadium Larva. Head creamy white mottled with mauve-brown. Prothoracic shield white with a broad median and a pair of narrower submarginal lines of mauve-brown. Suranal shield poorly distinguished from remainder of trunk. Mid-dorsal band dark brown with a pale median shade. Subdorsal area white with a pair of irregular, pale-mauve median lines. Supraspiracular area mauve-brown, paler dorsally than ventrally; mottled mesally with white. Spiracular band white with an irregular and discontinuous, mauve median band. Suprapodal area concolorous with supraspiracular area. Mid-ventral area grey variably suffused with mauve.

Head width: fourth-stadium larvae maturing in five stadia, 0.95 ± 0.06 mm (30 larvae); fifth-stadium larvae maturing in six stadia, 1.08 ± 0.04 mm (37 larvae).

Duration of stadium: fourth stadium of larvae maturing in five stadia, 7.6 ± 1.0 days (19 larvae); fifth stadium of larvae maturing in six stadia, 6.4 ± 1.0 days (31 larvae).

Ultimate-Stadium Larva. Head whitish-grey, heavily mottled with medium brown. Prothoracic shield white suffused and mottled with light brown and with a median and a pair of subdorsal lines devoid of darker shading. Suranal shield essentially undistinguished from remainder of trunk. Mid-dorsal band dull dark brown, with a variably expressed, paler, mauve median shade. Subdorsal area white marked with purplish-brown mesally and with a pair of mauve, median longitudinal lines. Supraspiracular area dark brown irregularly marked with mauve and cream. Spiracular band creamy-white with a discontinuous and irregular, mauve median line. Suprapodal area purplish-brown marked with cream. Mid-ventral area grey variably suffused with purplish-brown.

Head width: 1.75 ± 0.08 mm (25 larvae).

Acknowledgment

I appreciate the assistance of my associate, Mr. Eric Rockburne, in measuring the head widths of the larvae.

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GROTE, A. R. 1879. New noctuids. Can. Ent. 11: 197–199.

HARDWICK, D. F. 1958. Taxonomy, life history and habits of the elliptoid-eyed species of *Schinia* (Lepidoptera: Noctuidae) with notes on the Heliothidinae. Can. Ent. Suppl. 6.

THE LIFE HISTORY OF *SCHINIA WALSINGHAMI* (NOCTUIDAE)

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Schinia walsinghami (Hy. Edwards, 1881) feeds in the larval stage on rabbit brush, *Chrysothamnus nauseosus* Nutt. (Fig. 3). The moth is distributed in the Intermountain Basin area of western North America from the Okanagan Valley of British Columbia southward to southern California. Records available in the Canadian National Collection (Helena, Montana; Arvada and Alcova, Wyoming) suggest that the species occurs only marginally on the Great Plains, although the food plant itself is much more widely distributed.

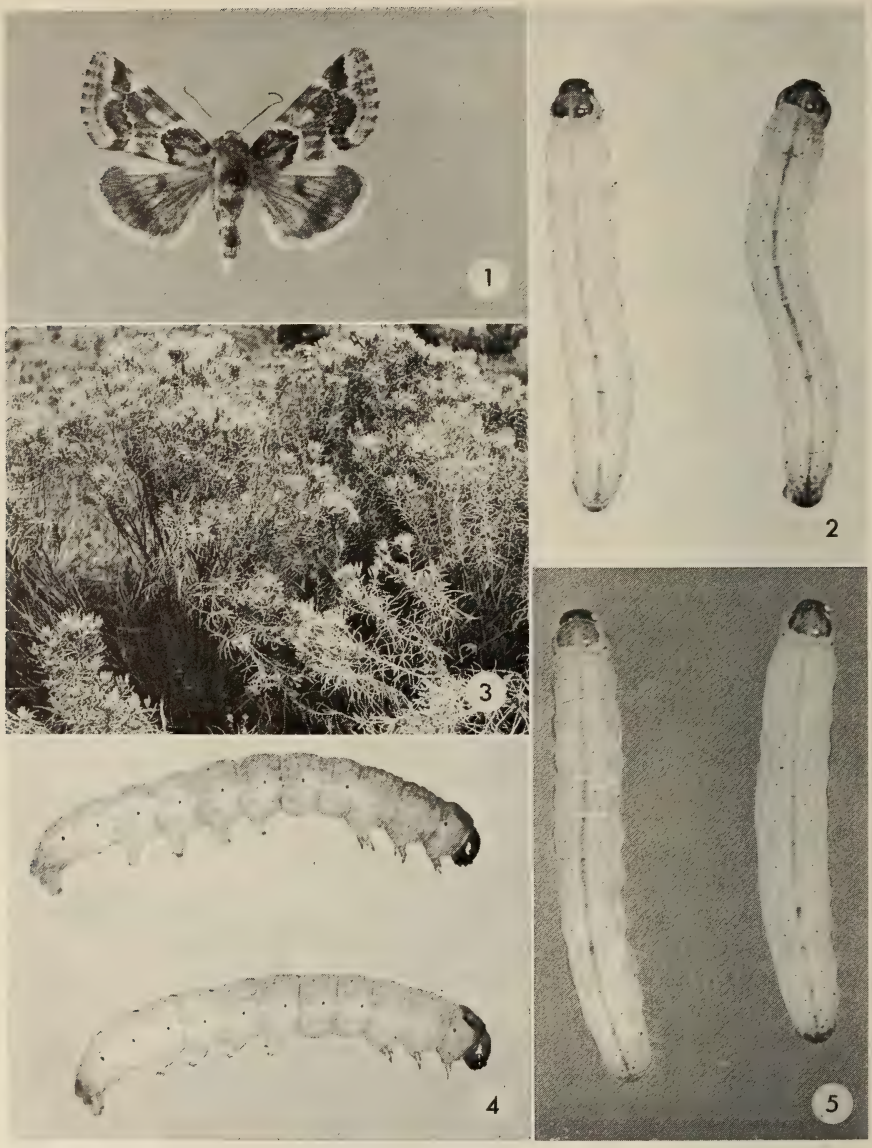
The flight period of *walsinghami* is closely co-ordinated with the late-summer blossoming period of *Chrysothamnus*, the majority of specimens examined having been taken in the latter half of August and during the month of September. The species is single-brooded throughout its range.

Behaviour

The adult of *Schinia walsinghami* is nocturnal and the eggs are deposited only during the hours of darkness. The oviposition pattern is similar to that of *Schinia separata* (Grt.) and the female works vigorously to deposit its eggs among the developing florets in the small hard buds of the rabbit brush. The ovipositor may be inserted through the top of a partially opened bud or between the stiff sepals forming the lateral walls of the bud. As with *separata*, the eggs are often badly distorted as a result of being wedged among the florets. Of two individually confined wild-caught females, one deposited a total of 69 eggs and the other 65. The majority of eggs hatched on the sixth day after deposition.

The newly hatched larva commonly bores into a floret and tunnels downward through it until it reaches the seed, then crosses over into an adjacent floret and tunnels upward through this. Usually early in the third stadium the larva leaves the first bud and attacks a second which it enters through the tip. By the time that it is in the late third stadium, the larva is becoming rather large to accommodate itself readily in the *Chrysothamnus* bud and often the caudal end may be found protruding from the apex of the bud. Fourth and fifth instars do not conceal themselves within individual buds but feed on them from a position on the stem, the larva reaching the florets by boring a hole through the sepals at the side of the bud.

All the individually reared larvae matured in five stadia. At the ces-



Figs. 1–5. *Schinia walsinghami* Hy. Edw. and its food plant. 1, Adult, Biggs, Oreg.; 2, 5, dorsal aspect of ultimate-stadium larvae; 3, food plant, *Chrysothamnus nauseosus* Nutt.; 4, lateral aspect of ultimate-stadium larvae.

sation of feeding the larva tunnels into the ground to form its pupal cell and it is in the pupal stage that the species overwinters.

Descriptions of Stages

The following descriptions of immature stages are based on the progeny of two females taken near Oliver in the Okanagan Valley of British Columbia. The larvae were reared individually at room temperature using methods outlined by Hardwick (1958). The estimate of variability following the mean for various values is the standard deviation.

Adult (Fig. 1). Head and thorax pale fawn-grey. Abdomen silvery-grey. Underside of body pale silvery-grey. *Forewing* light reddish-brown to golden fawn variably marked with white. Transverse posterior line white, strongly and usually smoothly excurved, sometimes weakly denticulate. Basal space reddish-brown to fawn, darker outwardly than at base, often with longitudinal pale streaking. Transverse posterior line white, bisinuate, excurved around cell, then incurved to trailing margin, usually strongly denticulate. Median space paler brown than basal space, rather diffusely marked and sometimes with some pale longitudinal streaking; median space often paler on either side so that white of t.a. and t.p. lines obscured; orbicular spot not defined and reniform spot usually indicated only as a dark shade. Subterminal line irregular, usually indented opposite cell and toward trailing margin. Subterminal space concolorous with basal space. Terminal space cream, variably suffused with light fawn; often a series of intervenal brown points at margin of wing. Fringe cream or pale fawn, often checkered with brown. *Hind wing* white or cream, variably suffused with brown; with a broad, light-brown outer-marginal band and a light-brown discal lunule. Outer-marginal band usually with a pale median streak. Fringe white, often with a brown median line. *Underside* of both wings shining greyish-cream, each with an indistinct, light-brown, discal spot and post-median band. Fringe of forewing cream, often checkered with brown; fringe of hind wing white.

Expanse: 24.2 ± 1.6 mm (100 specimens).

Egg. Pale greenish-yellow when deposited. Losing greenish colouring on day after deposition, then gradually becoming a somewhat darker yellow during the next few days. Mandibles, then ocelli, and then the whole head capsule becoming visible through chorion on the day of hatching.

Dimensions of egg: length, 0.791 ± 0.043 mm; diameter, 0.413 ± 0.023 mm (20 eggs).

Incubation period: 6.0 ± 0.2 days (63 eggs).

First-Stadium Larva. Head medium to dark brown. Prothoracic and suranal shields somewhat lighter brown. Trunk creamy-white on hatching but becoming stained with yellow after feeding.

Head width: 0.285 ± 0.008 mm (25 larvae).

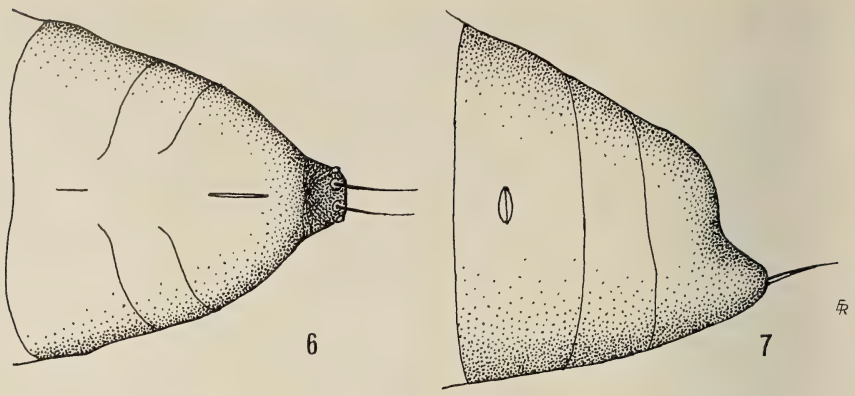
Duration of stadium: 4.6 ± 0.5 days (20 larvae).

Second-Stadium Larva. Head medium brown. Prothoracic and suranal shields lighter brown. Trunk greyish-white on entering stadium, becoming light yellow after feeding.

Head width: 0.440 ±0.019 mm (25 larvae).

Duration of stadium: 3.6 ± 0.5 days (20 larvae).

Third-Stadium Larva. Head orange-brown. Prothoracic shield orange-yellow with some light-brown mottling. Suranal shield essentially undistinguished from trunk. Mid-dorsal band orange-brown, narrow. Subdorsal area greyish-yellow margined laterally by a brown line. Supraspiracular area usually darker than, occasionally concolorous with, subdorsal area. Spiracular band dull white. Suprapodal area usually paler than supraspiracular area. Mid-ventral area pale greyish-yellow.



Figs. 6, 7. *Schinia walsinghami* Hy. Edw., apical abdominal segments of pupa. 6, Ventral; 7, right lateral.

Head width: 0.694 ± 0.019 mm (25 larvae).
Duration of stadium: 6.1 ± 0.7 days (20 larvae).

Fourth-Stadium Larva. Head orange-brown. Prothoracic shield paler orange-brown; variably marked with medium brown, most strongly so near margins. Suranal shield poorly distinguished from trunk, usually with some brown stippling. Mid-dorsal band orange-brown, the darkest area of trunk. Subdorsal area fawn, margined laterally by a pale-grey and a dark-brown lines. Supraspiracular area concolorous with subdorsal area. Spiracular band narrow, dull grey, poorly defined. Ventral region yellowish-grey.

Head width: 1.13 ± 0.04 mm (25 larvae).
Duration of stadium: 7.5 ± 0.5 days (20 larvae).

Fifth-Stadium Larva (Figs. 2, 4, 5). Head medium to dark orange-brown. Prothoracic shield paler, variably mottled with brown, most strongly so along lateral and posterior margins; a paler mid-dorsal line usually evident on shield. Suranal shield pale orange, variably stippled with brown. Trunk varying from translucent pale orange to translucent yellowish-grey; maculation of trunk usually indistinct. Mid-dorsal band orange-brown, narrow. Subdorsal area greyish-yellow. Supraspiracular area somewhat darker yellow than subdorsal area. Spiracular band reduced to a poorly defined, narrow pale shade. Ventral region pale greyish-yellow.

Head width: 1.73 ± 0.04 mm (9 larvae).
Duration of feeding phase of fifth stadium: 10.3 ± 2.0 days (20 larvae).
Duration of prepupal phase of fifth stadium: 5.6 ± 1.4 days (20 larvae).

Pupa (Figs. 6, 7). Pale yellowish-brown. Spiracles on abdominal segments 4 to 7 sunk into deep pits. Anterior margins of segments 5, 6 and 7 each with a broad band of prominent pitting. Proboscis terminating between apex of wings. Cremaster consisting of two slender setae borne on a short rounded prolongation of the tenth abdominal segment; a pair of vestigial lateral setae also usually evident.

Length from anterior end to posterior margin of fourth abdominal segment: 6.8 ± 0.2 mm (3 pupae).

Acknowledgments

I am grateful to Mr. John E. H. Martin of the Entomology Research Institute for the photographs accompanying this paper, and to my associate

Mr. E. W. Rockburne for measuring the immature stages and for drawing pupal structures.

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Hardwick, D. F. 1958. Taxonomy, life history, and habits of the elliptoid-eyed species of *Schinia* (Lepidoptera: Noctuidae), with notes on the Heliothidinae. Can. Ent. Suppl. 6.

DISTRIBUTION AND GEOGRAPHICAL DIFFERENTIATION OF *MARPESIA ELEUCHEA* HÜBNER (NYMPHALIDAE), WITH DESCRIPTIONS OF TWO NEW SUBSPECIES

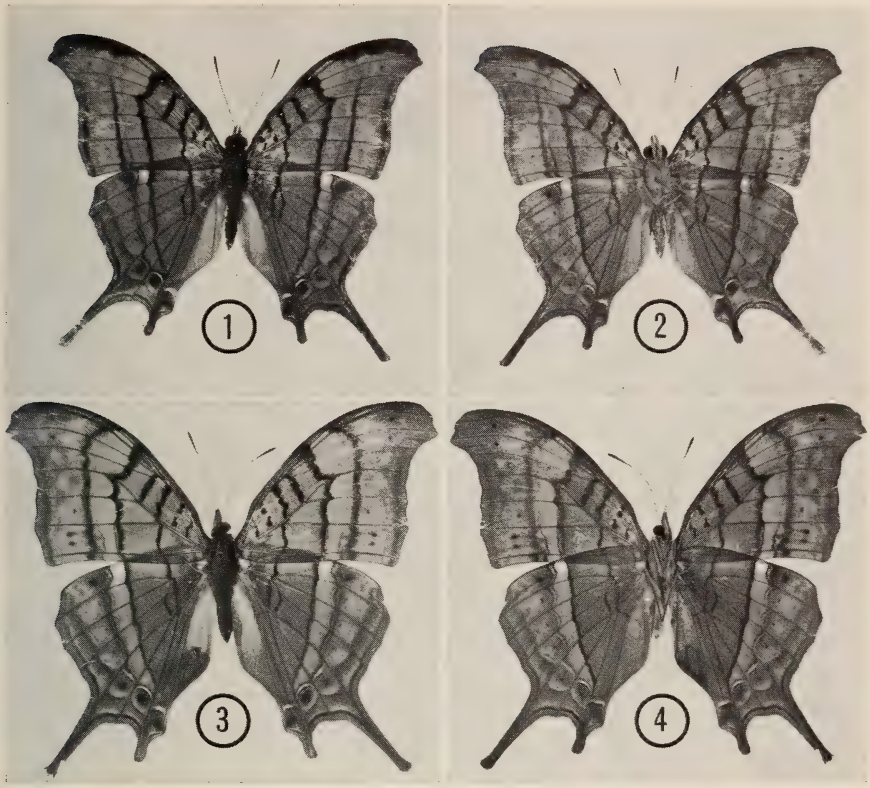
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The tailed butterfly *Marpesia eleuchea* Hübner appears, despite some doubtful continental records, to be an Antillean endemic. Records from the United States are based either on misidentified specimens of *M. petreus* (Cramer) (e.g., Slosson records from Miami) or on specimens of very doubtful provenance (e.g. the Doll specimen from "Central Florida" mentioned by Kimball (1965) and the "Southern States" specimen mentioned in the present paper). A record from Colombia discussed below is also highly suspect. The two species *M. eleuchea* and *M. petreus* are recognized by almost all authorities (e.g., dos Passos, 1964) as being distinct. Hemming's statement (1967, p. 277) that the two are currently treated subjectively as subspecies appears to be based on outdated information. Allowing for the wrong or questionable records noted above, the two are almost completely allopatric. *M. eleuchea* inhabits Cuba, Hispaniola, Jamaica and the Bahamas, whereas *M. petreus* has a mainland range extending from the southern United States far into South America, and also from Trinidad up the Lesser Antillean chain into the Virgin Islands and Puerto Rico, where *M. eleuchea* might have been expected but appears not to occur. There is a possible minor area of overlap in the Bahamas, where *M. eleuchea* occurs on New Providence and possibly other islands, while *M. petreus* is represented by a specimen in the British Museum (Natural History) labelled, "Bahamas, July 1921, J. M. St. J. Yates". However, it is not certain that the two species occur together on the same islands in the Bahama group.

This pattern of geographical replacement is of some evolutionary interest. The endemic West Indian *M. eleuchea* is the most closely similar species to *M. petreus*, but is manifestly more primitive; for example the shape of the wings and the configuration of the forewing bands are less divergent from those of more normal nymphalids, and the ocellate spots are less degenerate. It is reasonable to suppose that it is a West Indian stage of evolution of the stock which on the mainland has developed into the more strongly apomorphic *M. petreus*. The latter, however, has been successful in invading the West Indies via the Lesser Antilles. These small islands do not have a significant endemic butterfly fauna, but are populated by species of three geographical categories. First there are widespread species, some of which, like *Battus polydamas* (Linnaeus), have developed endemic subspecies and some of which, like *Ascia monuste* (Linnaeus), have not. Second, there are Greater Antillean species which have spread southward down part of the Lesser Antillean chain. An example is *Heliconius charitonius* (Linnaeus), whose subspecies reach St. Kitts. Third, there are South American species which have moved northward into the lesser Antilles, usually without differentiation, like *Biblis hyperia* (Cramer), but occasionally with minor subspeciation, as in *Mestra cana* (Erichson). *M. petreus* is an extreme example of the latter type. Not only has it occupied the whole of the Lesser Antilles but it has spread through the Virgin Islands and Puerto Rico as well. When Antillean endemics that occur in Hispaniola are represented in Puerto Rico as well, the two populations are usually identical or at least very similar. It is most ususual for an unmodified continental vicariant to occur in Puerto Rico instead, as in the present case. It seems very likely that *Marpesia eleuchea* originally inhabited Puerto Rico (and perhaps the Virgin Islands) as well as the other Greater Antilles, and that it has been displaced by competitive exclusion following the arrival of *M. petreus* from the south. An alternative hypothesis is that *M. eleuchea* never occurred in Puerto Rico or died out there before the arrival of *M. petreus*, which penetrated this "empty" habitat but has so far failed to establish itself sympatrically with *M. eleuchea* in Hispaniola.

It has been known for a long time that *M. eleuchea* has significant geographical variation in the Antilles. Bates (1935, p. 172), for example, said of *M. eleuchea*, "This choromorph is limited to Cuba and the Bahamas; specimens from Hispaniola and Jamaica (*pellenis* Godt) are less heavily marked." Some years ago when I was studying the biogeography of West Indian butterflies, the late Mr. William P. Comstock called my attention to the geographical variation of this species and indicated that Mr. C. F. dos Passos intended to work it out. At Mr. Comstock's sugges-



Figs. 1–4. *Marpesia eleuchea eleuchea* Hübner. 1, 2, ♂, Upper and under sides, Santiago de Cuba, F. E. Church, AMNH; 3, 4, ♀, upper and under sides, Santiago de Cuba, F. E. Church, AMNH.

tion, Mr. dos Passos kindly relinquished study of the problem to me and I set aside a type series of a manuscript subspecies from Hispaniola. The present paper describes that subspecies and another from the Bahamas, and compares these with the two named subspecies.

Marpesia eleuchea eleuchea Hübner

Figs. 1–4.

Marpesia eleuchea Hübner, 1818, p. 32, pl. [35], figs. 197, 198.
Marpesia eleuchea: Hübner, 1819, p. 47.
Marpesia eleuchea: Hübner [1823], pl. [50].
Nymphalis eleuchea: Poey, 1847, p. 47.
Marpesia eleucha: Doubleday, 1844, p. 86. In part.
Timetes (*Marpesia*) *eleucha*: Doubleday, Westwood and Hewitson, 1850, p. 263. In part.
Timetes eleuchea: Herrich-Schäffer, 1864, p. 161.
Megalura eleucha: Gundlach, 1881, p. 112.

Athena eleucha: Dyar, 1902, p. 25. In part.
Megalura eleuchea: Seitz, 1914, p. 470.
Athena eleuchea eleuchea: Bates, 1935, p. 172. In part.
Marpesia eleuchea: Comstock, 1944, p. 462. In part.
Marpesia eleucha: dos Passos, 1964, p. 74. In part.
Marpesia eleuchea: Hemming, 1967, p. 277. In syn. *M. petreus* (Cramer).

Male. Forewing short, termen erect and with moderately produced subapical angle. Upperside fulvous, with three oblique black bars in cell, the second broken, the third produced to anal vein. A black bar on discocellular. Three black lines between cell and termen: the first oblique to M_3, there angled and erect to posterior margin; the second narrow, anteriorly faint and weakly curved; the third thick, a little diffuse, parallel to termen. Apical area infuscated.

Hind wing above similar in colour. A black line from costa to Cu, traversing cell. A bent, broken, black bar at end of cell. A narrow black postmedial line, erect from costa to Cu_2, there curving basad and fading out. Three subterminal bands. The first fuscous, diffuse, preceded on costa by a white shade and followed by a greyish apical shade, weakly converging with postmedial to M_3, there bent basad and scalloped to form basal edges of three large, grey, suffused, ocellate spots. The second subterminal band diffuse, fuscous, converging with the first from near apex to M_3, thence scalloped to form distal borders of ocellate spots. The third subterminal band narrower, better defined, close to and parallel to termen, forming a deep dentation into the tail. Anal area suffused with greyish fuscous, the suffusion not taking in all of the first ocellate spot. Tail white-tipped. Anal lobe blue-suffused.

Underside brown with violet tints, paler beyond middle, leaf-like. Forewing with first cell-band reduced, curved, brown. Second cell-band broken in middle. Third cell-band narrow, irregular, black, distally pale-edged. Discocellular bar grey, edged with fuscous powdering. Postmedial line light grey, followed by dark brown, forming the midrib of the leaf-like pattern. A complete series of poorly defined ocellate spots, bordered by weak, scalloped, brown, first and second subterminal lines. Third subterminal line following same course as on upperside, but very weak.

Hind wing beneath coloured like forewing. Pattern elements occupying same positions as above, but with a complete series of ocellate spots.

Female. Upperside like that of male, but much duller fulvous, lines thicker. Forewing and hind wing with suggestions of complete series of ocellate spots, defined outwardly by greyish-fuscous suffusion. Whole terminal area suffused with greyish or brownish fuscous. Apical suffusion of forewing brownish fuscous, not black.

Underside like that of male, but grey rather than brown.

Type. The type is, so far as I know, lost, but Hübner gives the locality Havana, Cuba.

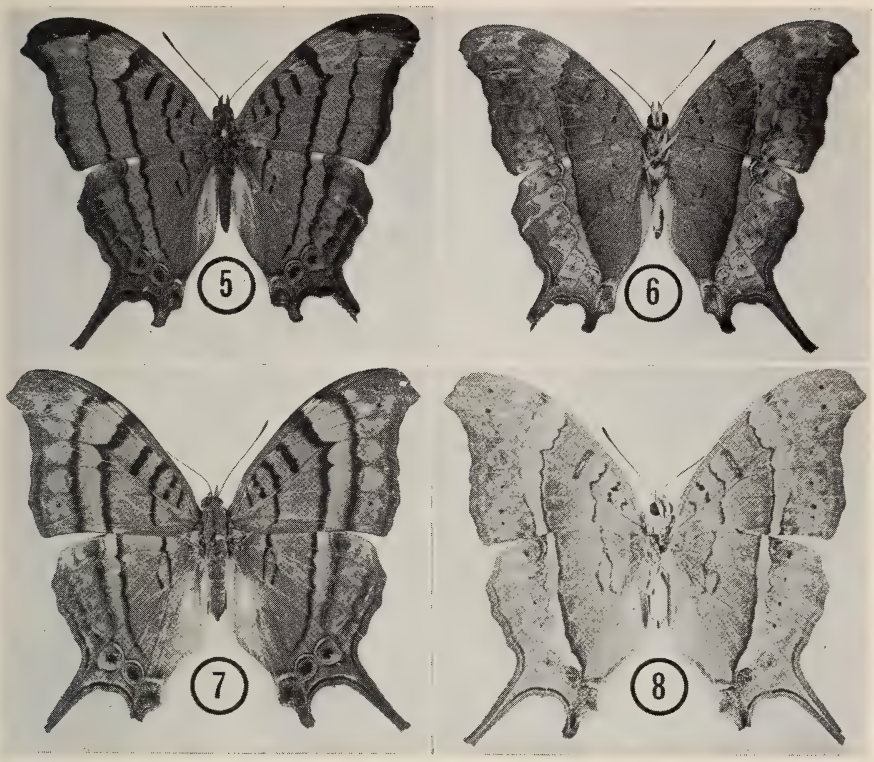
Material examined. Eighty-three specimens, from Cuba: Rangel, P. del R.; Havana, June; Nueva Gerona, I. of Pines, Aug.; Santiago de las Vegas, July; Camagüey, April; Soledad, Sta. Clara, July; Matanzas, July; Santiago de Cuba, 200 ft., June; Torquino R., 100 ft. July; Sierra Maestra, 1000 ft., March, June; Loma del Gato, Sierra Maestra, 850 m., July; Guantánamo, June; Baracoa; Holguin; Rio Cano, March; Tanamo, March; San Christobal. Two specimens labelled Guacomo, Colombia, F. E. Church, appear to belong to this subspecies.

Marpesia eleuchea bahamensis Munroe, **new subspecies**

Figs. 5–8

Athena eleuchea eleuchea: Bates, 1935, p. 172. In part.

Male. As in the nominate subspecies, with the following differences. Size a little smaller on average. Markings of forewing slightly heavier. Hind wing above with apex grey-suffused from first subterminal band to termen. Second subterminal band



Figs. 5–8. *Marpesia eleuchea bahamensis* n. subsp. 5, 6, Holotype, ♂, upper and under sides, Nassau, Bahamas, F. E. Taylor, BM (NH). 7, 8, allotype, ♀, upper and under sides, Nassau, Bahamas F. E. Taylor BM(NH).

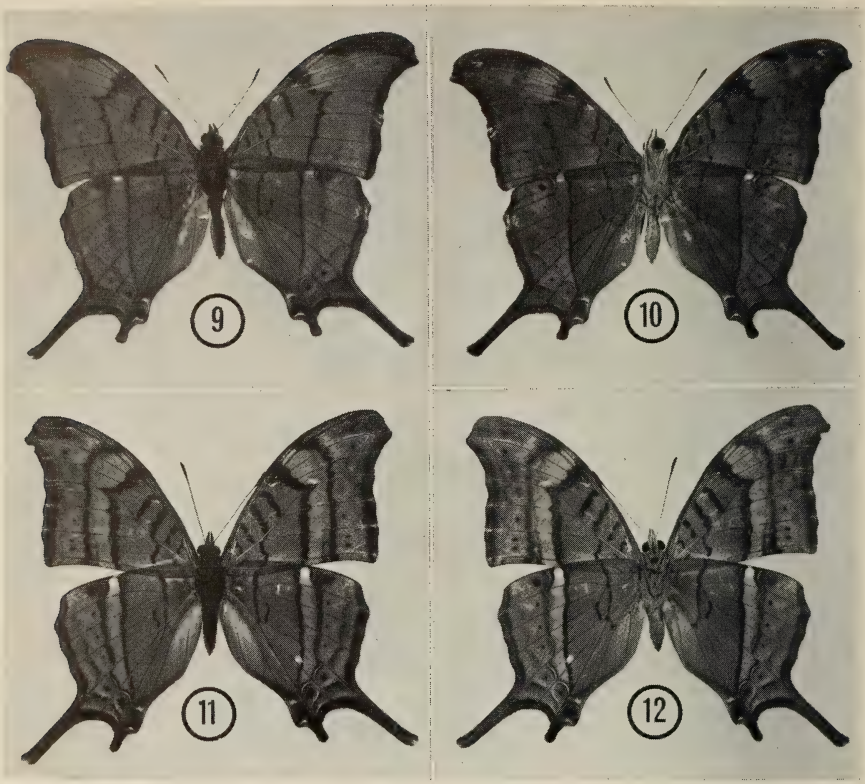
diffuse, with fuscous suffusion extending weakly distad to termen. Third subterminal line heavier. Anal area with greyish-fuscous suffusion more extensive, completely encompassing first ocellate spot as well as second and third. Basal margins of ocellate spots each with a strong white lunular marking. Some light-grey suffusion in outer parts of ocellate spots and in some specimen also along third subterminal band posteriad of tail.

Underside purplish grey, with weak markings.

Female. Larger and duller than male. Like female of the nominate subspecies, but with bands of forewing above heavier. Hind wing with more fuscous and grey suffusion and stronger white anal markings, as in male.

Underside light grey, with weak markings.

Types. Holotype, male, and allotype, female, Nassau, Bahamas, F. E. Taylor, In British Museum (Natural History). Three male and 3 female paratypes in the British Museum (Natural History) from the Bahamas: [Andros?], N. Chamberlain; Nassau, J. L. Bonhote, F. E. Taylor; "Bahamas, 10.6.1900", Sir G. Carter. Four additional paratypes in the Museum of Comparative Zoology, Cambridge, Mass., from the Bahamas: Nassau, June; Andros, July; Arthur's Town, Cat. I., July. In the Carnegie Museum one paratype Blue Hills, Nassau, Jan.



Figs. 9–12. *Marpesia eleuchea dospassosi* n. subsp. 9, 10, Holotype, ♂, upper and under sides, Punta Arena, San Lorenzo, Rep. Dominicana, 24 June 1915, F3177. AMNH; 11, 12, allotype, ♀, upper and under sides, Pétionville, Haiti, 12 June 1930, F. E. Church, AMNH.

Marpesia eleuchea dospassosi Munroe, **new subspecies**

Figs. 9–12

Marpesia eleuchea pellenis: Bates, 1935, p. 172. In part.

Male. Coloured like the nominate subspecies. Forewing above with subapical angle on the average more rounded and termen more shallowly curved and oblique. Postcellular continuation of the third cell-stripe tending to be displaced basad. Anterior part of postmedial band strongly thickened towards costa. First subterminal line faint posteriorly, nearly obsolete anteriorly. Apical black suffusion wide, continued around apex to join expanded outer subterminal band. The latter wide, black and reaching nearly to termen.

Hind wing above with discocellular bar tending to be weak. First postmedial line usually narrow and broken. Second postmedial line nearly obsolete anterior to M_2. Ocellate spot in cell M_3 largely fulvous.

Wings below as in nominate subspecies but variable in colour, from grey through tan to dark brown.

Female. Upperside closely similar to that of the nominate subspecies, but with

terminal area more broadly and heavily suffused with brownish fuscous on forewing and hind wing.

Underside as in nominate subspecies, but with ocellate spots more distinct.

Types. Holotype, male, Punta Arena, San Lorenzo, Dominican Republic, 24 June 1915, F3177, in the American Museum of Natural History. Allotype, female, Pétionville, Haiti, 12 June 1930, F. E. Church, in the American Museum of Natural History. Five male, 3 female paratypes in the American Museum of Natural History, same data as holotype, and: La Romana, Dominican Republic, 14 Dec., G. N. Wolcott; Rio Macosia, 8 km. south of Las Matas, Dominican Republic, 5 July 1957, O. Cucurullo Jr.; Pétionville, Haiti, 3 June 1930, F. E. Church; Cit. La Ferrière, Haiti, 2,500 ft., 6 June 1935. Five male, 4 female paratypes in the British Museum (Natural History): "Haiti", Tweedie; Port-au-Prince, Haiti, F. Odile Joseph; "Gulf of Mexico, P. E. Cheesman"; [Haiti], ex coll. Chris. Ward. Five paratypes in the Cornell University Collection: Pétionville, Haiti, May, June; Monte Christi, Dominican Republic, June. Three paratypes in the Museum of Comparative Zoology, Cambridge, Mass.: "San Domingo".

Marpesia eleuchea pellenis (Godart)

Figs. 13–16

Nymphalis pellenis Godart, 1819, p. 359.
Marpesia pellenis: Doubleday, 1844, p. 86. In syn. of *M. eleucha.*
Timetes (*Marpesia*) *pellenis*: Doubleday, Westwood and Hewitson, 1850, p. 263. In syn. of *T. eleucha.*
Megalura eleucha: Kaye, 1931, p. 533. In part.
Athena eleuchea pellenis: Bates, 1935, p. 172. In part.
Marpesia eleuchea: Comstock, 1944, p. 462. In part.
Marpesia eleuchea pellenis: Avinoff and Shoumatoff, 1946, p. 280.

Male. Like *M. e. dospassosi* in colour. Forewing with subapical angle more acute and termen more strongly excavated than in other subspecies. Transverse lines finer. Postcellular continuation of third cell line displaced basad, very fine. Postmedial line moderately expanded towards costa. First subterminal line very weak, especially anteriorly. Third subterminal narrow, removed from termen, interrupted or nearly so between M_1 and M_2. Apical patch extending to subapical angle, its posterior margin nearly straight, oblique.

Hing wing above with discocellular line weak or absent. Postmedial and first subterminal lines narrower than in *M. e. dospassosi.* First ocellate spot almost wholly fulvous. Third subterminal line narrow.

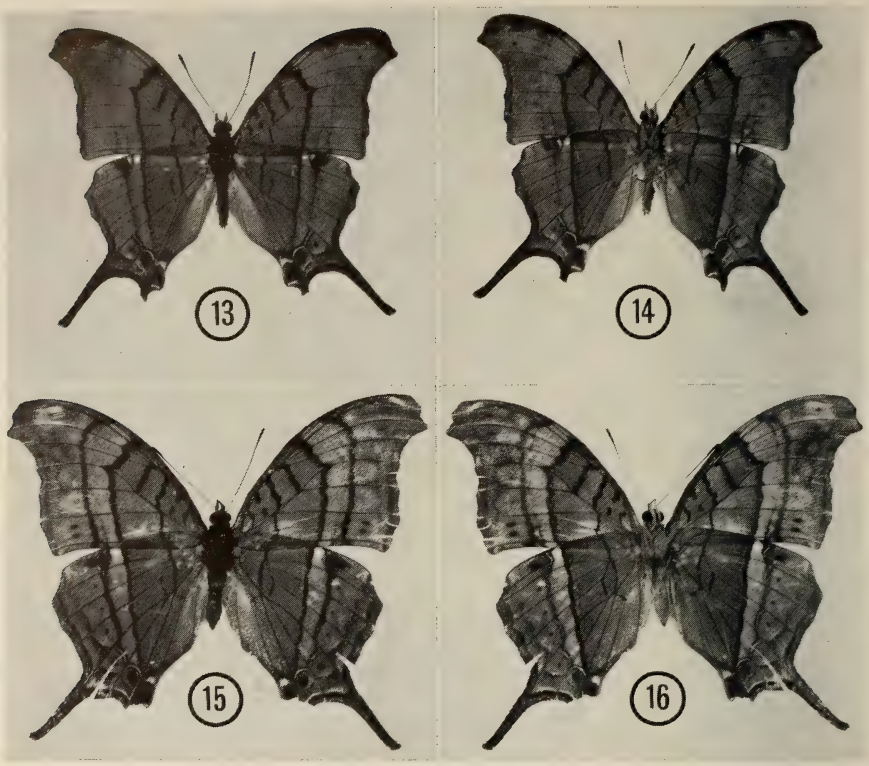
Underside as in *M. e. dospassosi.*

Female. Smaller and paler than the female of *M. e. dospassosi.* Transverse lines narrower than in other subspecies. Costal, apical and terminal suffusion of forewing and hind wing greatly reduced.

Underside as in *M. e. dospassosi.*

Type. Godart described *pellenis* from a specimen without exact locality, of which he said, "Nous la soupçonnons des Antilles." The material studied by Godart came from several collections, and though I think it doubtful that his type still exists it is possible it may yet be discovered. I therefore refrain from designating a neotype. His description refers to the absence of the third black line, i.e., the first subterminal, which would point to either this subspecies or the preceding one, but does not give any hint as to which of the two Godart had. I consider that he is as likely to have received a Jamaican specimen as one from Haiti, and I therefore arbitrarily restrict the type locality to Jamaica, making the name applicable to the present subspecies.

Material Examined. Thirty specimens from Jamaica: Montego Bay, May; Baron Hill, Trelawny, 1,150 ft., Aug., Sept., Oct., Nov.; Reading, St. James; Hope Botanic



Figs. 13–16. *Marpesia eleuchea pellenis* (Godart). 13, 14, Male, upper and under sides, Hope Botanic Gardens, St. Andrew, Jamaica, 5 Dec. 1919, F4455, AMNH; 15, 16, ♀, upper and under sides, Baron Hill, Trelawny, Jamaica, Nov. 1935, AMNH.

Gardens, St. Andrews; Fish River, Portland; Constant Spring, 650 ft.; Rae Town, Aug.; Albion, July; Milk River, June. Also one specimen without locality, and one labelled "Southern States, No. 1442, Coll. J. Angus, West Farms, New York."

Acknowledgments

I wish to express appreciation to Mr. C. F. dos Passos and the late Mr. William P. Comstock for encouraging me to undertake this study. The late Mr. F. E. Watson, the late Dr. A. Avinoff, the late Dr. Wm. T. M. Forbes, Professor V. Nabokov, Dr. P. J. Darlington Jr. and Dr. F. H. Rindge lent material or helped in other ways. Mr. T. G. Howarth helped me to examine material at the British Museum and kindly provided photographs of the types of *Marpesia eleuchea bahamensis*. Messrs. Orrin Hanright and D. Kritsch made the remaining photographs and Mr. Kritsch

mounted the plates. Mr. E. C. Pelham-Clinton gave prompt and helpful information on specimens in the Dufresne Collection in the Royal Scottish Museum, Edinburgh, and Dr. Pierre Viette verified the absence of type material in the Muséum d'Histoire Naturelle, Paris.

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SEVEN NEW LEPIDOPTEROUS LEAF-MINERS ASSOCIATED WITH *QUERCUS AGRIFOLIA* (HELIOZELIDAE, GRACILARIIDAE)

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Division of Entomology
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During the course of a study of the bionomics of Microlepidoptera associated with *Quercus agrifolia* Neé (Fagaceae) in California, it was found that a number of the species are undescribed. In order to provide names for use elsewhere, one new heliozelid and six new gracilariids are herein described. Because the genitalia of the Nearctic members of these families have not been previously studied, the works of Kumata (1963), Kuroko (1961), and Vari (1961) provided bases of homologies and diagnostic features in the genitalia of these moths.

Descriptions in this paper use the holotype and allotype as exemplars. The holotype and allotype of each species are deposited in the California Academy of Sciences, San Francisco, on indefinite loan from the California Insect Survey, University of California, Berkeley. Paratypes are deposited in the American Museum of Natural History, New York; California Academy of Sciences; California Insect Survey; Canadian National Collection, Ottawa; Los Angeles County Museum; and U.S. National Museum, Washington, D.C.

Coptodisca powellella Opler, **new species**

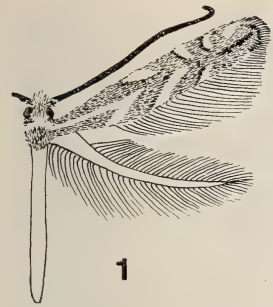
Male. Length of forewing 1.5 to 1.7 mm (reared).

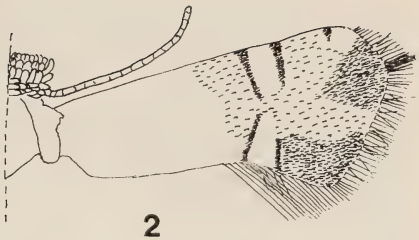
HOLOTYPE MALE. Length of forewing 1.6 mm. *Forewing*: Basal half metallic silver; distal half with pattern as follows: a basal orange patch extending from costa almost to inner margin; followed distally by two opposing triangular patches of silver, one on costal margin, one on inner margin, apices not quite joining; these patches narrowly margined with black basally and distally; costal area orange distal to triangular patches except for subapical black margined silver patch and black apex. Dorsal area black distal to silver patch on inner margin. *Abdomen*: Blackish dorsally, silver ventrally. *Genitalia*: As in Figs. 9, 10, 12, 14, 15 (drawings from paratype, PAO prep. 323); uncus shallowly bilobed at tip.

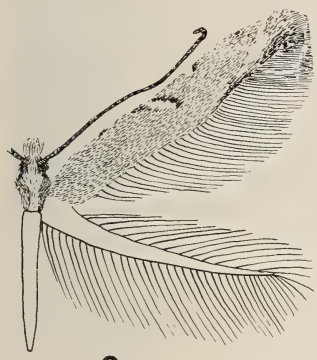
Female. Length of forewing 1.6 to 1.9 mm (reared).

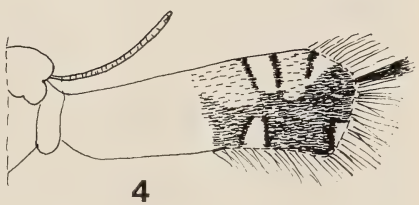
ALLOTYPE FEMALE. Length of forewing 1.7 mm. External features as described for male. *Genitalia*: As in Figs. 28, 29, 30. Comparison with genitalia of other oak-feeding *Coptodisca* was not made. Thus, the included drawings serve only to portray the structures which may later prove to be of diagnostic value.

Type Material. *Holotype male*: California, Descanso Ranger Station, San Diego County, 31 March 1961, reared from *Quercus agrifolia* Neé, J. Powell lot 61C22, emerged 21 April 1961, collected by J. Powell. *Allotype female*: same data except emerged 12 April 1961. *Paratypes*: 66 ♂♂, 83 ♀♀ as follows: **California.**—Contra Costa Co.: Clayton, 6 mi. SE, 1 ♀, II-2-68, r.f. *Q. agrifolia*, J. Powell lot 68B18,



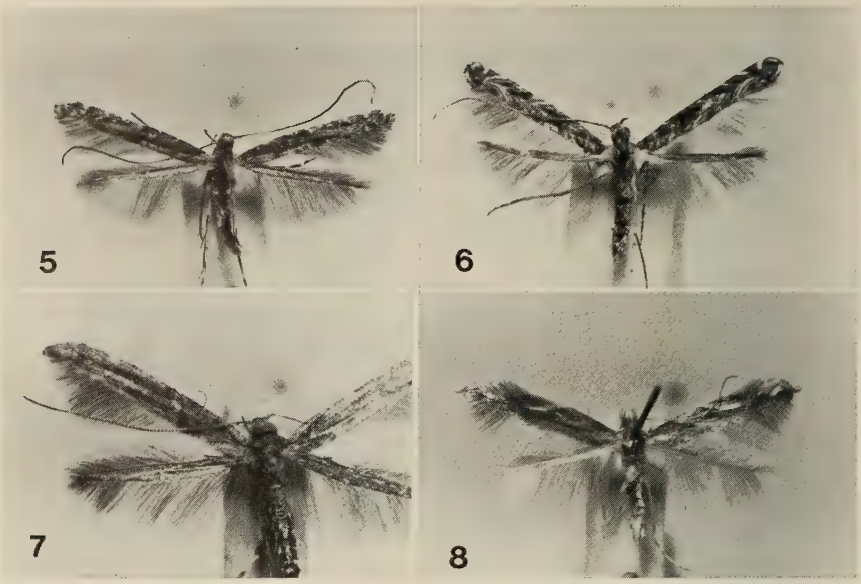






Figs. 1–4. 1, *Lithocolletis antiochella* Opler, ♂, right forewing, holotype; 2, *Coptodisca powellella* Opler, ♂, right forewing, Descanso Ranger Station, San Diego Co., Calif. 31 March 1961 r.f. *Quercus agrifolia* JAP 61C22 emgd. 18 April 1961, J. Powell collector; 3, *Cameraria wislizeniella* Opler, ♂, right forewing, holotype; 4, *Coptodisca querciella* Braun, ♂, right forewing, paratype, Cornville, Yavapai Co., Ariz. r.f. *Quercus emoryi* B1241 emgd. 1 May 1925, H. Brisley collector.

emgd. III-20-68 (P. Opler); Cowell, 1♀, II-28-68, r.f. *Q. agrifolia*, J. Powell lot 68B193, emgd. IV-10-68 (P. Opler). Los Angeles Co.: Santa Monica Mts., 3♂♂, 3♀♀, III-17-69, r.f. *Q. agrifolia*, J. Powell lot 69C68, emgd. IV-3/10-69 (P. Opler). Monterey Co.: Arroyo Seco Camp, 4♂♂, II-12-68, r.f. *Q. agrifolia*, J. Powell lot 68B53, emgd. III-27/IV-5-68 (P. Opler). Placer Co.: Penryn, 1♂, III-13-68, r.f. *Q. wislizenii*, J. Powell lot 68C14, emgd. IV-8-68 (P. Opler). Riverside Co.: Mountain Center, 1♂, III-16-68, r.f. *Q. wislizenii* var. *frutescens*, J. Powell lot 68B127, emgd. III-17-68 (P. Opler). San Bernardino Co.: Forest Home, 1 mi. W, 3♂♂, 5♀♀, III-29-68, r.f. *Q. wislizenii* var. *frutescens*, J. Powell lot 68C77, emgd. IV-27/V-7-68 (P. Opler). San Diego Co.: Descanso Rgr. Sta., 5♂♂, 6♀♀, III-31-61, II-15-68, r.f. *Q. agrifolia*, J. Powell lots 61C22, 68B110, emgd. IV-10/21-61, II-14/23-68 (P. Opler, J. Powell). Warner Springs, 1 mi. NW, 32♂♂, 42♀♀, II-15-68, r.f. *Q. agrifolia* var. *oxyadenia*, J. Powell lot 68B118, emgd. III-12/IV-5-68 (P. Opler). Santa Barbara Co.: Los Prietos, 1 mi. E, 10♂♂, 12♀♀, II-13-68, r.f. *Q. agrifolia*, J. Powell lot 68B76, emgd. III-14/IV-5-68 (P. Opler); Santa Cruz Island, Prisoner's Harbor, 4♂♂, 5♀♀, III-14-69, r.f. *Q. agrifolia*, J. Powell lot 69C24, emgd. IV-8/14-69 (P. Opler, J. Powell); Santa Cruz Island, U. C. Field Sta., 1♂♂, 7♀♀, III-15-69, r.f. *Q. agrifolia*, J. Powell lot 69C48, emgd. III-27/IV-6-69 (P. Opler).

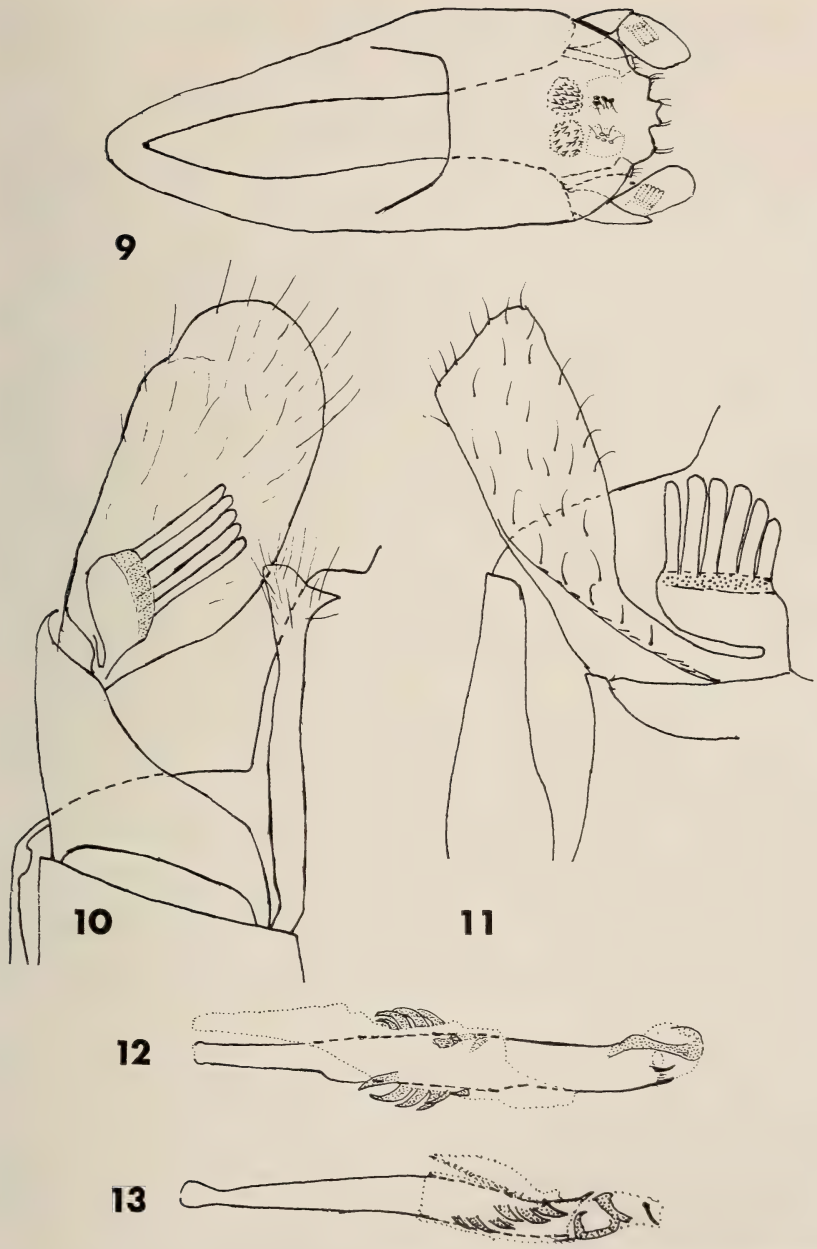


Figs. 5–8. 5, *Acrocercops insulariella* Opler, ♀, Central Valley, Santa Cruz Island, Santa Barbara Co., Calif., 28 April 1966 r.f. *Quercus agrifolia* JAP 66D45, emgd. 31 May 1966, J. Powell and J. Wolf collectors; 6, *Neurobathra bohartiella* Opler, ♂, Strawberry Canyon, Alameda Co., Calif. 30 July 1968, r.f. *Quercus agrifolia* JAP 68G73, emgd. 13 August 1968, P. Opler collector; 7, *Caloptilia agrifoliella* Opler, ♀, two miles southest of Inverness, Marin Co., Calif., 13 April 1968, r.f. *Quercus agrifolia* JAP 68D1333, emgd. 12 May 1968, P. Opler collector; 8, *Lithocolletis sandraella* Opler, ♂, Descanso Ranger Station, San Diego Co., Calif., 31 March 1961, r.f. *Quercus agrifolia* JAP 61C24, emgd. 9 April 1961, J. Powell collector.

The only previously described western oak-feeding member of this genus is *C. querciella* Braun. In her description of *C. querciella*, Braun (1927) delineates only the maculation features of the adult and states that the host is an evergreen species of *Quercus*. Through Dr. Braun's courtesy I was able to examine leaf mines as well as a male paratype from Cornville, Yavapai County, Arizona, the type locality. The leaf which harbored the mines of *C. querciella* proved to be *Quercus emoryi*, a species which is consubgeneric with the hosts of *C. powellella*.

C. powellella differs from *C. querciella* in features of forewing maculation. The former has extensive orange markings and restricted black markings, while the latter has less extensive orange and more extensive black (Figs. 2, 4).

The most obvious differences in the male genitalia are in the aedeagi and apparent aedeagal sheaths of the two species. The "aedeagal sheath" of *C. powellella* is proportionately larger than that of *C. querciella* and



Figs. 9–13. Male genitalia of *Coptodisca*. 9, *C. powellella* Opler, dorsal aspect, aedeagus removed; 10, *C. powellella*, left valva, ventral aspect; 11, *C. querciella* Braun, left valva, ventral aspect; 12, *C. powellella*, aedeagus and "aedeagal sheath" lateral aspect; 13, *C. querciella*, aedeagus and "aedeagal sheath", lateral aspect.

is of a somewhat different shape, while other apparent differences are shown by the tips of the aedeagi (Figs. 12, 13).

Acrocercops insulariella Opler, **new species**

Male. Length of forewing, 3.7 to 4.5 mm (reared).

HOLOTYPE MALE. Length of forewing 4.2 mm. *Head*: Maxillary palpus with outer side black scaled, inner side white scaled. Labial palpus primarily white scaled basally, black scaled distally. Antenna longer than wing, uniformly blackish gray. Vestiture of front mixed brownish-gray and gray white. Vestiture of vertex brownish-gray. *Thorax*: Scaling of dorsum and tegulae brownish-gray; scaling of pleural and ventral areas predominantly white with some light gray scales intermixed. Prothoracic leg with femur dirty white, tibia gray, tarsomeres gray black ringed with white; mesothoracic leg with femur white ventrally, blackish-gray dorsally, tibia black with white basoventrally and a white ring around middle, tarsomeres black, ringed with white; metathoracic leg with femur white, tibia white ventrally, black dorsally, tarsomeres black, variously marked with white. *Forewing*: Ground mixed brown and orangish brown; several small patches of five to ten white scales as follows: seven along costal margin, four along inner margin. Underside dark brown. Fringe brown with two patches of white scales at distal end of costa, a few black-tipped white scales at wing tip, and a few white scales in fringe at distal end of inner margin. *Hind wing*: Upperside, underside, and fringe gray brown. *Abdomen*: Gray black dorsally, white ventrally. *Genitalia*: As in Figs. 17, 18 (drawings from Paratype, PAO prep. no. 139); valvae with dorsal margin straight, margin of cucullus slightly convex distally to meet costal margin at bluntly subtriangulate tip, inner face densely covered with setae on distal .8; tegumen .75 length of valvae, distal margin quadrate in ventral view, weakly setate; saccus short; aedeagus with one pointed cornutus at tip.

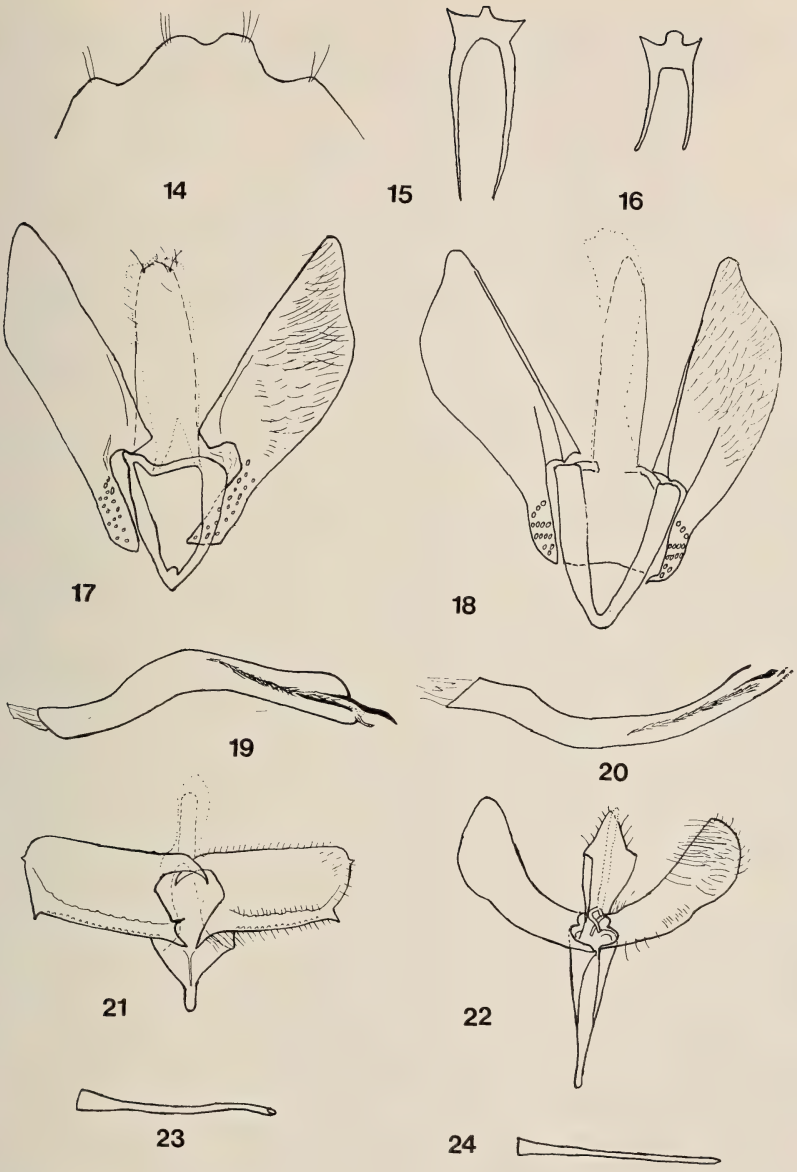
Female. Length of forewing 4.3 to 4.7 mm (field collected).

ALLOTYPE FEMALE. Length of forewing 4.5 mm. External features as described for male. *Genitalia*: Aphophyses anteriores slightly recurved. Ductus bursae with rib-like sclerotizations at .66 from opening. Signum a caliper-shaped sclerotization.

Type Material. Holotype male: California, Santa Cruz Island, Central Valley, Santa Barbara County, 28 April 1966, reared from *Quercus agrifolia* Neé, J. Powell lot 66D45, emerged 31 May 1966, collected by J. Powell, A. Slater, and J. Wolf. *Allotype female*, California, Santa Cruz Island, Eagle Canyon east of Prisoner's Harbor, 9 June 1966, collected by J. A. Powell. *Paratypes*: 6♂♂, 3♀♀ as follows: **California.**—Santa Barbara Co.: Santa Cruz Island, Prisoner's Harbor Creek, 4♂♂, 1♀, IV-28-66, r.f. *Q. agrifolia*, J. Powell Lot 66D45, emgd. V-26/31-66 (J. Powell, A. Slater, J. Wolf); Santa Cruz Island, Eagle Cyn., E of Prisoner's Harbor, 2♂♂, 1♀, VI-9-68 (J. Powell).

Acrocercops insulariella differs from *A. affinis* Braun (1918), the only previously described oak-feeding species which occurs in the west, by features of forewing maculation and the male genitalia. Through the courtesy of Dr. Braun I was able to examine male and female paratypes from Camp Baldy, San Bernardino County, California, the type locality.

Although the two species are closely related there are slight but constant differences. The forewing of *A. affinis* has a pale white patch on the inner margin two-fifths from the base which has quadrate darkened patches to either side. These features are not present in individuals of *A. insulariella*.



Figs. 14–24. Male genitalia. 14, *Coptodisca powellella* Opler, tip of uncus, dorsal aspect; 15, *C. powellella*, transtilla, dorsal aspect; 16, *Coptodisca querciella* Braun, transtilla, dorsal aspect; 17, *Acrocercops insulariella* Opler, ventral aspect, aedeagus removed; 18, *A. insulariella*, aedeagus, lateral aspect; 19, *Acrocercops affinis* Braun, ventral aspect, aedeagus removed; 20, *A. affinis*, aedeagus, lateral aspect; 21, *Neurobathra bohartiella* Opler, ventral aspect aedeagus removed; 22, *N. bohartiella*, aedeagus, lateral aspect; 23, *Caloptilia agrifoliella* Opler, ventral aspect, aedeagus removed; 24, *C. agrifoliella*, aedeagus, lateral aspect.

The male genitalia of the two species differ in that the uncus of *A. insulariella* is truncate with two prominent long setae distally, while the uncus of *A. affinis* is subacuminate distally and has several short setae.

Neurobathra bohartiella Opler, **new species**

Male. Length of forewing 4.5 to 4.9 mm (reared).

HOLOTYPE MALE. Length of forewing 4.7 mm. *Thorax*: Scaling of dorsum and tegulae tan; scaling of pleural and ventral areas silvery gray. Prothoracic leg with femur blackish, tibia silvery gray, tarsomeres white basally, black distally; mesothoracic leg with femur white anteriorly, blackish posteriorly, tarsomeres white ventrally, black dorsally with black distally; metathoracic leg with basal .25 of femur blackish, distal .75 white, tibia white ventrally, gray dorsally, tarsomeres black basally, white distally. *Forewing*: Ground gray brown; ground scaling on distal third of wing tipped with tan; a black mark on costa .3 from base, three narrow, black, outwardly directed streaks on costa near .75 from base; three narrow, white, outwardly directed streaks on costa at from .5 to .8 from base; a white, subapical patch on costa; a large white streak curving outwardly from inner margin .75 from base. Underside brown. Inner fringe at wing tip black; outer fringe at wing of black-tipped white scales giving fringe a black-white-black pattern; remainder of fringe brown. *Abdomen*: Brownish-gray dorsally, white ventrally. *Genitalia*: As in Figs. 21, 22 (drawings from Holotype, PAO prep. no. 173); valvae almost half as broad as long, truncated distally; two short, stout, triangulate projections at distal end, the ventral largest; costal margin of valva straight.

Female. Length of forewing 4.1 to 4.7 mm (reared).

ALLOTYPE FEMALE. Length of forewing 4.3 mm. External features as described for male. *Genitalia*: Anterior margin of seventh segment a heavily sclerotized ring. Anterior portion of corpus bursae sclerotized with small finger-like projections interiorly.

Type Material. *Holotype male*: California, Strawberry Canyon, Alameda County, 30 July 1968, reared from *Quercus agrifolia* Neé, J. Powell lot 68G73, emerged 13 August 1968, PAO prep. no. 173, collected by P. Opler. *Allotype female*: California, Golden Gate Park, San Francisco County, 26 February 1968, reared from *Q. agrifolia*, J. Powell lot 68B181, emerged 6 March 1968, collected by P. Opler. *Paratypes*: 4♂♂, 4♀♀ as follows: **California.**—Alameda Co.: Berkeley, 1♂, III-1-59 (J. Powell); Strawberry Cyn., 1♂, VII-30-68, r.f. *Q. agrifolia*, J. Powell lot 68G73, emgd. VIII-13-68 (P. Opler). Los Angeles Co.: Westwood Hills, 1♀, IV-41, Acc. 309 (R. M. Bohart). Mendocino Co.: Yorkville, 6 mi. SE, 1♀, V-18-66 (A. J. 10-69, r.f. *Q. agrifolia*, J. Powell lots 68B33, 68LB, 69B6, emgd. II-19-68, XII-15-Slater). San Francisco Co.: Golden Gate Park, 2♂♂, 1♀, II-6-68, XI-15-68, II-10-69, r.f. *Q. agrifolia*, J. Powell lots 68B33, 68L5, 69B6, emgd. II-19-68, XII-15-68, II-7-69 (P. Opler). Santa Barbara Co.: Refugio Beach, 3 mi. N, 1♀, VII-4-65 (J. Powell).

Neurobathra bohartiella is apparently the only representative of the genus in California. *Neurobathra strigifinitella* (Clemens), the only other described species in the genus, occurs in eastern North America. The genitalia of *N. bohartiella* differ from that of *N. strigifinitella* as figured by Vari (1961) as follows: the costal margin of the valva of *N. bohartiella* is straight while that on *N. strigifinitella* is slightly concave. Additionally the upper tooth on the distal margin of the valva is relatively smaller for *N. bohartiella* than for *N. strigifinitella*.

The life cycles of the two species differ in that pupae of *N. strigifinitella* undergo an obligatory pupal diapause (*fide* T. N. Freeman), while the life cycle of *N. bohartiella* lacks any form of diapause.

Caloptilia agrifoliella Opler, **new species**

Male. Length of forewing 6.2 to 7.0 mm (reared).

Holotype male. Length of forewing 6.8 mm. *Head*: Maxillary palpus yellow scaled inwardly, mixed yellow and russett outwardly. Labial palpus yellow scaled basally, mixed yellow and russet distally. Antenna slightly longer than forewing; scape orange scaled; flagellar segments yellowish basally, blackish distally. Vestiture of front and vertex brownish orange. *Thorax*: Scaling of dorsum and tegulae brownish orange with bluish iridescence in reflected light; scaling of pro- and mesothoracic pleural areas orange; scaling of metathoracic pleural areas yellowish. Prothoracic leg with femur yellowish-orange; tibia and basal tarsomeres orangish-brown; remainder of tarsomeres silvery white, narrowly ringed with black distally. Mesothoracic leg with femur and tibia dark orangish-brown; tarsomeres white, narrowly ringed with black distally. Metathoracic leg with femur white-scaled, tibia white ventrally, gray dorsally; tarsomeres white, ringed narrowly with dark gray distally. *Forewing*: Brownish-orange with ill-defined yellowish orange areas on costa; a bluish sheen in reflected light. Underside gray black narrowly edged with orange. Fringe gray black. *Hind wing*: Upperside, underside, and fringe gray black. *Abdomen*: Scaled gray black dorsally, white ventrally. *Genitalia*: As in Figs. 23, 24 (drawings from Paratype, PAO prep. no. 148); valva becoming broader distally, slightly truncated at tip, twice as broad distally as at base; dorsal margin flaring; ventral margin with shallow convex lobe at .5 from base, inner face of lobes with about 15 peg-like setae arranged in three rows; anterior corner of valva with a patch of about 30 stout, pointed setae; distal half of valva covered with long hair-like setae on inner face. Tegumen sclerotized, broader and longer than vinculum, triangulate in distal half, basal half with ventrally directed flaps. Tuba analis membranous, projecting beyond vinculum, with weakly sclerotized median ridge. Saccus as long as length of valva, narrow, acuminate distally. Aedeagus tubular, pointed at tip, lacking cornuti. Coremata of two groups of hair-like scales, one group with scales more than 3 × length of the other.

Female. Length of forewing 6.2 to 6.8 mm (reared).

Allotype female. Length of forewing 6.6 mm. Externally as described for male. *Genitalia*: Ninth segment ventrally with posteriorally directed peg-like projection. Eighth segment with a deep membranous invasion just posterior and ventral to apophyses anteriores. Signa two slightly curved, cone-like projections.

Type Material. *Holotype male*: California, one mile southeast Inverness, Marin County, 2 May 1969, reared from *Quercus agrifolia* Neé, J. Powell lot 69E76, emerged 19 May 1969, collected by P. Opler. *Allotype female*: California, two miles southeast Inverness, Marin County, 13 April 1968, reared from *Q. agrifolia*, J. Powell lot 68D133, emerged 12 May 1968, collected by P. Opler. Paratypes: 5♂♂, 10♀♀ as follows: **California.**—Alameda Co.: Strawberry Cyn., 1♂, 2♀♀, IV-11-68, r.f. *Q. agrifolia*, J. Powell lot 68D124, emgd. IV-7/V-25-68 (P. Opler). Marin Co.: Inverness, 1 mi. SE, 1♂, 5♀♀, V-10-68, V-2-69, r.f. *Quercus agrifolia*, J. Powell lots 68E19, 69E76, emgd. V-30-68, V-19/23/69 (P. Opler, J. Powell); Inverness, 2 mi. SE, 3♀♀, IV-13-68, r.f. *Q. agrifolia*, J. Powell lot 68D133, emgd. V-12/14/68 (P. Opler). Monterey Co.: Bixby Cyn., 1♂, VII-27-48 (J. W. Tilden). San Francisco Co.: Golden Gate Park, 1♂, VII-30-67, r.f. *Q. agrifolia*, J. Powell lot 67G22, emgd. VIII-25-67 (P. Opler). Santa Barbara Co.: Santa Cruz Island, Prisoner's Harbor, 1♂, VI-7-66 (R. L. Langston).

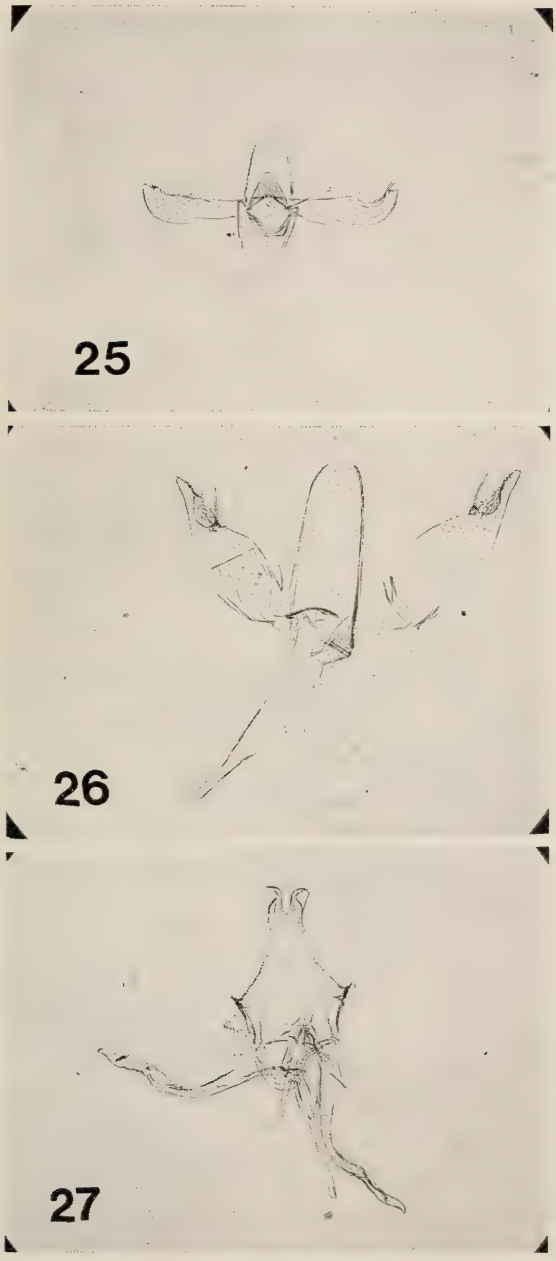
Caloptilia agrifolia can be distinguished from *Caloptilia reticulata* (Braun), the only other described oak-feeding species of the genus occurring in California, on the basis of life cycle features, larval shelter, maculation, and genitalia. *C. agrifoliella* is normally single-brooded, but is facultatively double-brooded, feeds only on young foliage, and has a pupal diapause which usually lasts through the summer, fall and winter. The larval shelter is a rolled leaf. *C. reticulata* is homodynamically multiple-brooded, feeds on older foliage, and lacks any type of diapause. The larval shelter consists of a singly folded leaf. The vestiture on the dorsum of the thorax and tegulae of *C. agrifoliella* is unicolorous; and the forewing is variously colored orangish, tan, or rust colored with faint light areas and black marks. The male genitalia is distinguished by the long acuminate saccus, rounded valvae, and triangulate tegumen. The vestiture on the dorsum of the thorax of *C. reticulata* is reddish-orange, while that of the tegulae is straw-colored, and the forewing is reddish-orange with numerous straw-colored splotches. The male genitalia are distinguished by the short saccus, truncated valvae, and rounded tegumen.

The names *Gracilaria sanguinella* Beutenmüller, *Gracilaria nigristrigella* Beutenmüller, *Gracilaria ruptistrigella* Beutenmüller, *Gracilaria shastella* Beutenmüller described in 1888, and *Gracilaria fuscoochrella* Beutenmüller described in 1889 were synonymized by Ely (1917) under *Gracilaria alnivorella* Chambers. McDunnough (1946) restricted the name *alnivorella* to an alder feeding species of eastern North America and did not include Beutenmüller's names in the synonymy of that species.

Remnants of the Beutenmüller holotypes are located in the U.S. National Museum and were examined by J. A. Powell. The present state of these types is as follows:

G. sanguinella—"1358 California." No abdomen. No host given.
G. nigristrigella—"1333 California." All that remains of the type is one hind wing. Collected on oak tree.
G. ruptistrigella—"1327 California." The specimen is broken in half. No host given.
G. shastella—No abdomen. No host given.
G. fuscoochrella—No abdomen. No host given.

These names could apply to any of a number of Californian *Caloptilia* species which feed on *Acer*, *Alnus*, *Lithocarpus*, or *Quercus*. Because features of the genitalia and host plant are the main criteria for assigning specific status to the moths of this genus and because the above listed Beutenmüller names cannot be evaluated on either basis, I treat them as *nomena dubia*.



Figs. 25–27. Male genitalia, ventral aspect. 25, *Lithocolletis antiochella* Opler; 26, *Lithocolletis sandraella* Opler; 27, *Cameraria wislizeniella* Opler.

Lithocolletis antiochella Opler, **new species**

Male. Length of forewing 2.7 to 3.9 mm (reared).

HOLOTYPE MALE. Length of forewing 3.5 mm. *Head*: Maxillary palpus brownish-tan scaled, antenna tan, slightly shorter than length of forewing costa. Vestiture of front shining white; vestiture of vertex, brownish-tan. *Thorax*: Scaling of dorsal portion and anterior half of tegulae brown, whitish at anterior margin; posterior halves of tegulae white-scaled. Pleural and ventral areas with shining white scaling. Legs with shining white scaling except for black scaling on: dorsal halves of femora, tibia, and tarsi of pro- and meso-thoracic legs. A tuft of long white scales on ventral half of tibiae. *Forewing*: Brown, shining gold in reflected light; a white stripe from base through median portion of wing along basal .4 of length, a white dorsal streak at .2 distance from base, directed outwardly and joining basal median stripe; two pairs of opposite white streaks narrowly edged with black inwardly, the basal pair .33 from base directed sharply apically, not quite joining, the dorsal streak largest, distal pair small, triangulate, each extending .33 width of wing; a median streak of black scales on termen not quite reaching wing tip; wing tip edged narrowly with black. Underside brown. Fringe pale tan. *Hind wing*: Upperside pale tan. Underside brownish-tan. Fringe pale tan. *Abdomen*: Tan dorsally, whitish ventrally. *Genitalia*: As in Fig. 25 (photograph from Paratype, PAO prep. no. 246); valvae asymmetrical, both valvae with width gradually increasing distally, dorsal margins strongly decurved; right valva ending with a short, stout spine directed posteroventrally, ventral margin straight; left valva with ventral margin with a concavity just basal to distal end; saccus short, triangular, well sclerotized; transtilla well sclerotized; aedeagus straight, narrow, and sclerotized basally, broadened and weakly sclerotized for distal .33; uncus acutely triangular; flap of ninth sternite long, subacute at tip.

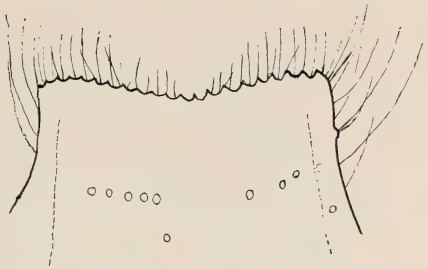
Female. Length of forewing 2.7 to 3.9 mm (reared).

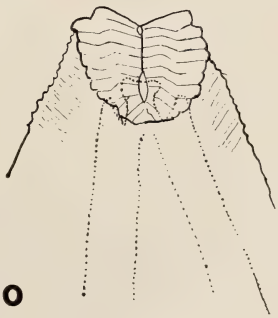
ALLOTYPE FEMALE. Length of forewing 3.2 mm. Externally as described for male. *Genitalia*: Eighth segment completely membranous. Posterior margin of seventh segment concave ventrally at opening of ductus bursae. Signum bursae a small round sclerotization with stout seta-like projection.

Type Material. *Holotype male*: California, 2 miles east of Antioch, Contra Costa County, 28 February 1968, reared from *Quercus agrifolia* Neé J. Powell lot 68B198, emerged 5 March 1968, collected by P. Opler. *Allotype female*: same data. *Paratypes*: 35♂♂, 51♀♀ as follows: **California**.—Alameda Co.: Strawberry Cyn., 1♂, VII-30-68, r.f. *Q. agrifolia*, J. Powell lot 68G71, emgd. II-12-69 (P. Opler). Contra Costa Co.: Antioch, 2 mi. E, 24♂♂, 22♀♀, II-2-68, II-28-68, r.f. *Q. agrifolia*, J. Powell lots 68B2, 68B198, emgd. II-15/19-68, III-1/10-68 (P. Opler), 7♂♂, 27♂♂, II-28-68, III-26-69, *Q. agrifolia* assoc. (P. Opler, J. Powell, C. Slobodchikoff); Cowell, 2♂♂, 1♀, II-28-68, II-16-69, r.f. *Q. agrifolia*, J. Powell lots 68B192, 69B16, emgd. III-7-68, II-21-69 (P. Opler); Russell Farm, 4 mi. NE Orinda, 1♀, III-6-70, *Q. agrifolia* assoc. (P. Opler). Los Angeles Co.: Westwood Hills, no abdomen, IV-41, r.f. *Q. agrifolia* (R. M. Bohart). Ventura Co.: Newbury Park, 1♂, IX-5-69, r.f. *Q. agrifolia*, J. Powell lot 69J28, emgd. XII-15-69 (P. Opler).

Its life history, maculation, and genitalic features set *Lithocolletis antiochella* apart from all other members of the genus. Among the species treated by Braun (1908) in her revision of the North American *Lithocolletis*, *Lithocolletis diaphanella* Frey and Boll appears to be most closely related in external appearance to *L. antiochella*. *L. antiochella* differs from *L. diaphanella* in that the vestiture of the palpi, antennae, and vertex are brown, not white; that there are three dorsal white streaks instead of two; and that the forewings are brown in color as opposed to







Figs. 28–30. *Coptodisca powellella* Opler, female genitalia. 28, Genital apparatus, ventral aspect; 29, posterior portion of eighth segment, ventral aspect; 30, tip of abdomen showing distal portion of ovipository apparatus.

golden brown. A comparison of the genitalia of these species was not carried out.

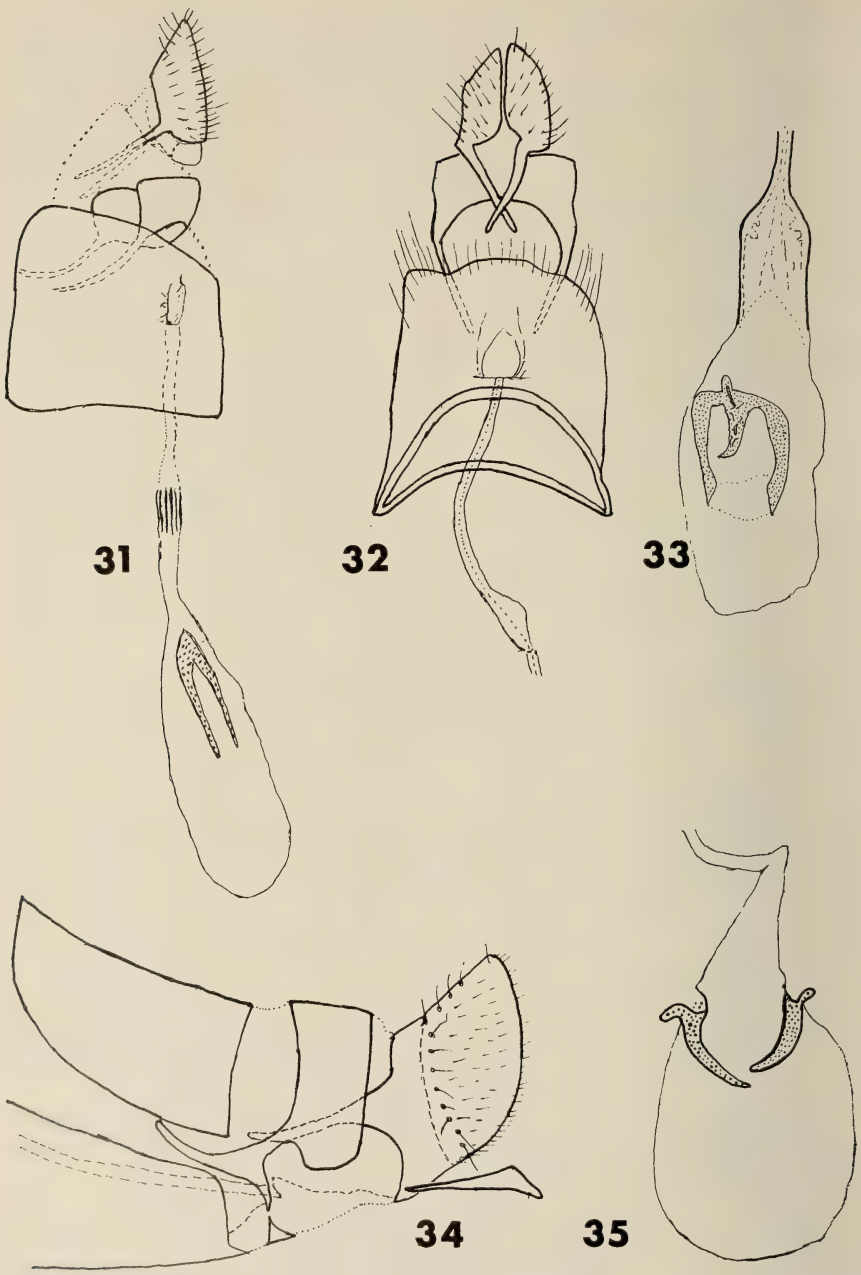
The male genitalia of *L. antiochella* have a well sclerotized diaphragma, asymmetrical valvae which are broader distally than basally. The eighth abdominal segment of the female is completely membranous.

The larvae feed on young foliage in the spring and then undergo a pupal diapause of about ten months.

Lithocolletis sandraella Opler, **new species**

Male. Length of forewing 2.9 to 4.7 mm (reared).

HOLOTYPE MALE. Length of forewing 3.8 mm. *Head*: Maxillary palpus white scaled. Antenna tan, slightly longer than .5 costal length. Vestiture of front shining white; vestiture of vertex light orange-tan with a few scattered white scales laterodorsally. *Thorax*: Pronotal scaling and tegulae orange-tan with two narrow white



Figs. 31–35. Female genitalia. 31, *Acrocercops insulariella* Opler, latero-ventral aspect; 32–33, *Neurobathra bohartiella* Opler, ventral aspect; 34, *Caloptilia agrifoliella* Opler, lateral aspect, corpus bursa removed; 35, *C. agrifoliella* corpus bursa.

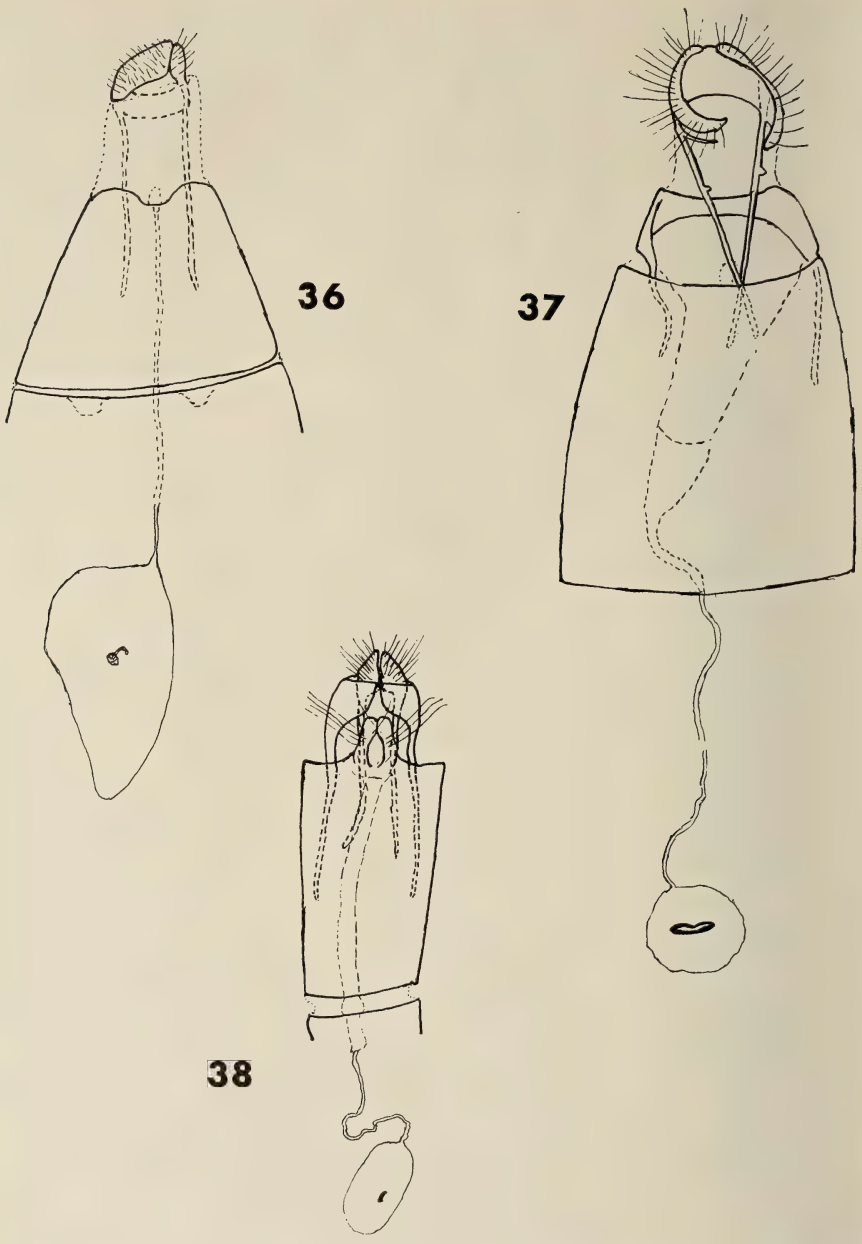
streaks along junction of inner margin of tegulae with dorsum of thorax. Pleural and ventral areas with white scaling. Legs white-scaled except dorsal halves of profemur and protibia fuscous scaled. *Forewing*: Ground orange-tan, a thin white stripe from base through median portion of wing for .35 length, a white mark at middle of costal margin directed postero-apically and terminating at point on median of width and .66 length from base, a patch of black-tipped scales running from inner termination of costal white mark to subapical area; at apex fringe with basal row of black-tipped scales. Underside dark tan. Fringe tan with long tuft of black scales at apex. *Hind wing*: Upperside white. Underside tan. Fringe white. *Abdomen*: Black dorsally, white ventrally. Genital segments with tan scaling externally. *Genitalia*: As in Fig. 26 (photograph from Paratype, PAO prep. no. 250); valvae symmetrical, broad at base (width about .33 length), narrowing distally with tip bluntly acuminate, a crescentic hollow area on ventral margin near apex containing patch of short, stout setae, a stout filament-like seta .25 length of valva at inner edge of hollow area directed ventrodistally; flap of ninth sternite long, parallel-sided, gradually rounded apically.

Female. Length of forewing 3.5 to 5.5 mm (reared).

ALLOTYPE FEMALE. Length of forewing 4.3 mm. External features as described for male except dorsum of abdomen pale tan-scaled. *Genitalia*: As in Fig. 37. Apophyses posteriores with small triangulate projections .33 from base; apophyses anteriores short. Genital plate enlarged, heavily sclerotized, inserted into seventh segment. Signum bursa an elongate lip-like sclerotization.

Type Material. *Holotype male*: California, Descanso Ranger Station, San Diego County, 31 March 1961, reared from *Quercus agrifolia* Neé, J. Powell lot 61C24, emerged 5 April 1961, collected by J. Powell. *Allotype female*: same data. *Paratypes*: 13♂♂, 20♀♀ as follows: Alameda Co.: Berkeley, 1♂, III-7-69, r.f. *Q. agrifolia*, J. Powell lot 69C5, emgd. III-20-69 (P. Opler); Berkeley Hills, above Old Tunnel, 1♀, VIII-25-68, r.f. *Q. agrifolia*, J. Powell lot 68H16, emgd. IX-3-68 (P. Opler). Contra Costa Co.: Cowell, 1♂, II-28-68, r.f. *Q. agrifolia*, J. Powell lot 68B194, emgd. IV-5-68 (P. Opler); Tilden Park, 1♂, IV-16-69, r.f. *Q. agrifolia*, J. Powell lot 69D31, emgd. IV-27-69 (P. Opler). Kern Co.: Keene, 2♀♀, X-1-67, r.f. *Q. wislinzenii*, J. Powell lot 67K9, emgd. X-7/20-67 (P. Opler). Los Angeles Co.: Malibu Cyn., 5 mi. N. Malibu, 1♀, III-17-69, r.f. *Q. agrifolia*, J. Powell lot 69C59, emgd. III-2-69 (P. Opler); Topanga Cyn., 1♂, III-17-69 r.f. *Q. agrifolia*, J. Powell lot 69C58, emgd. III-31-69 (P. Opler). Monterey Co.: Carmel, 1♀, X-2-27 (L. S. Slevin); Jolon, 17.5 mi. W, 3♂♂, 1♀, III-19-69, r.f. *Q. wislizenii*, J. Powell lot 69C87, emgd. IV-6-69 (P. Opler). Orange Co.: Silverado, 1♂, III-30-68 (P. Opler). San Benito Co.: Limekiln Cyn., SW Paicines, 1♀, IV-23-69, r.f. *Q. agrifolia*, J. Powell lot 69D55, emgd. V-7-69 (P. Opler). San Diego Co.: Descanso Rgr. Sta., 2♂♂, 2♀♀, III-31-61, r.f. *Q. agrifolia*, J. Powell lot 61C24, IV-7/14-61 (J. Powell), 1♀, III-31-61 (R. L. Langston); Guatay, 1 mi. W, 2♀♀, IX-13-68, r.f. *Q. agrifolia* var. *oxyadenia*, J. Powell lot 68J73, emgd. IX-21/24-68 (P. Opler); Honey Spgs. Rd., 1♂, X-4-67, r.f. *Q. agrifolia*, J. Powell lot 67K51, emgd. X-31-67 (P. Opler). San Francisco Co.: Golden Gate Park, 1♀, IV-5-68, r.f. *Q. agrifolia*, J. Powell lot 68D49, emgd. IV-23-68 (P. Opler). San Luis Obispo Co.: La Panza Camp, 1♀, IV-25-68, r.f. *Q. agrifolia*, J. Powell lot 68D131, emgd. V-7-68 (P. Opler). Santa Barbara Co.: Santa Cruz Island, Prisoner's Harbor, 2♀♀, III-14-69, r.f. *Q. agrifolia*, J. Powell lot 69C23, emgd. III-31-69 (P. Opler). Santa Clara Co.: Herbert Crk., 3 mi. W New Almaden, 1♀, IV-25-69, r.f. *Q. agrifolia*, J. Powell lot 69D71.1, emgd. V-7-69 (P. Opler). Ventura Co.: Newbury Park, 2♂♂, 3♀♀, IX-5-69, r.f. *Q. agrifolia*, J. Powell lot 69J27, emgd. IX-6/11-69 (P. Opler).

Lithocolletis sandraella is quite unlike any other North American species of the genus. Perhaps *Lithocolletis inusitatella* Braun is the species



Figs. 36–38. Female genitalia, ventral aspect. 36, *Lithocolletis antiochella* Opler; 37, *Lithocolletis sandraella* Opler; 38, *Cameraria wislizeniella* Opler.

with which *L. sandraella* should be compared. Both *L. sandraella* and *L. inusitatella* have *Quercus agrifolia* and *Q. wislizenii* as their only hosts. *L. sandraella* lacks the metallic bronze sheen and apical black spot displayed by the forewings of *L. inusitatella*. *L. sandraella* differs strikingly from *L. inusitatella* in genitalic features as well. The valvae of *L. sandraella* are symmetrical while those of *L. inusitatella* are asymmetrical. Additionally, *L. sandraella* is bivoltine, while *L. inusitatella* is univoltine.

Cameraria wislizeniella Opler, **new species**

Male. Length of forewing 3.1 to 4.7 mm (reared).

Holotype male. Length of forewing 3.8 mm. *Head*: Maxillary palpus white scaled. Antenna as long as costal length; scape white ventrally, brownish orange dorsally, flagellum fuscous scaled dorsally, tan ventrally. Vestiture of front shining white; vertex white mesally, narrowly margined with brownish orange laterally. *Thorax*: Scaling of dorsum broadly white mesally, brownish-orange laterally; tegulae brownish-orange; pleural and ventral areas with shining white scaling. Prothoracic leg black dorsally, white ventrally, tarsomeres ringed with white; mesothoracic leg white, tarsomeres black, ringed with white; metathoracic leg with femur white, tibia white ventrally, brownish-orange dorsally, tibia and tarsa predominantly white, with small black mark on dorsal surface at junction of tibia and tarsus and junction of first and second tarsomeres. *Forewing*: Ground bronzy brownish-orange; an outwardly directed narrow white streak on costa at .5 forewing length from base, narrowly edged at outer margin with black, a broken narrow white stripe extending from tornus to wing tip edged anteriorally with white. Underside blackish fuscous. Fringe brownish-orange apically, gray white posteriorally. *Hind wing*: Upperside shining gray white. Underside gray. Fringe gray white. *Abdomen*: Gray black dorsally and laterally, white ventrally. *Genitalia*: As in Fig. 27 (photograph from Paratype, PAO prep. no. 231); valvae symmetrical, narrow, broadest basally, sinuous, falcate apically; a single row of setae on inner face of valva extending from base to .5 length; a patch of longer setae on inner face of valva at ventral margin .66 from base, uncus long, acuminate, two slender setae at distal tip; flap of ninth sternite long, distal half triangulate, deeply cleft distally to separate two truncate lobations.

Female. Length of forewing 2.4 to 4.3 mm (reared).

Allotype female. Length of forewing 3.4 mm. As described for male except: inner margin of forewing narrowly edged with white on basal half (this characteristic present on many males). Dorsal scaling of abdomen pale tan. *Genitalia*: As in Fig. 38 (drawing from Paratype, PAO prep. no. 338); opening of ductus bursae surrounded by posterad bilobed projection. Signum bursae consisting of a small triangular sclerotization.

Type Material. *Holotype male*: California, Knight's Ferry, Stanislaus County, 20 March 1968, reared from *Quercus wislizenii* A. D. C., J. Powell lot 68C46, emerged 24 March 1968, collected by J. T. Doyen. *Allotype female*: California, Woodacre, Marin County, 15 March 1968, reared from *Quercus wislizenii* var. *frutescens* Engelm., J. Powell lot 68C23.1, emerged 8 April 1968, collected by P. Opler. *Paratypes*: 37 ♂ ♂, 26 ♀ ♀ as follows: **California.**—Contra Costa Co.: Antioch, 2 mi. E, 30 ♂ ♂, 21 ♀ ♀, II-2-68, II-28-68, IV-7-68, V-26-68, r.f. *Q. agrifolia*, J. Powell lots 68B4, 68B199, 68D56, 68E47, emgd. II-14/19, III-7/26, IV-13/25, VI-6/14 (P. Opler); Clayton, 4 mi. SE, 1 ♀, V-26-68, r.f. *Q. wislizenii*, J. Powell lot 68E65, emgd. by II-11-69 (P. Opler); Clayton, 8 mi. SE, 1 ♂, II-2-68, r.f. *Q. wislizenii*, J. Powell lot 68B13, emgd. II-20-68 (P. Opler); Mt. Diablo, summit, 3849′, 1 ♀, IV-13-69, r.f. *Q. wislizenii* var. *frutescens*, J. Powell lot 69D141, emgd. IV-24-69

(P. Opler). Marin Co.: Woodacre, 3♂♂, III-15-68, r.f. *Q. wislizenii* var. *frutescens*, J. Powell lot 68C23.1, emgd. IV-5/8-68 (P. Opler). Monterey Co.: Jolon, 17.5 mi. W, 1♂, III-19-69, r.f. *Q. wislizenii*, J. Powell lot 69C86, emgd. III-31-69 (P. Opler). Placer Co.: Penryn, 1♂, 2♀♀, III-13-68, r.f. *Q. wislizenii*, J. Powell lot 68C15, emgd. III-23/IV-8-68 (P. Opler). San Bernardino Co.: Forest Home, 1 mi. W, 1♀, III-29-68, r.f. *Q. wislizenii* var. *frutescens*, J. Powell lot 68C79, emgd. IV-23/V-1-68 (P. Opler). Stanislaus Co.: Knight's Ferry, 1♂, III-29-68, r.f. *Q. wislizenii*, J. Powell lot 68C46, emgd. IV-10-68 (J. T. Doyen).

Among described species of the genus, the closest relative of *Cameraria wislizeniella* is *Cameraria mediodorsella* (Braun). These moths are very similar in maculation and are difficult to separate on that basis, but the two have distinctive male genitalia. The male genitalia of *C. wislizeniella* differs by the distally expanded valvae, the relatively uncurved aedeagus, and the attenuate flap of the ninth sternite.

The life cycle of *C. wislizeniella* is typified by the absence of diapause while that of *C. mediodorsella* has a pupal diapause over the winter months.

Acknowledgments

I wish to thank the following for the loan of material from their private or institutional collections: P. H. Arnaud, Jr., California Academy of Sciences, San Francisco; A. F. Braun, Cincinnati, Ohio; D. R. Davis, U.S. National Museum, Washington, D.C.; J. A. Powell, California Insect Survey, Berkeley; R. O. Schuster, University of California, Davis; J. W. Tilden, San Jose, California.

J. A. Powell provided helpful suggestions and reviewed the manuscript of this paper. Miss Susan McDonald made the illustrations of adult *Lithocolletis antiochella* and *Cameraria wislizeniella*. My wife Sandra provide secretarial assistance.

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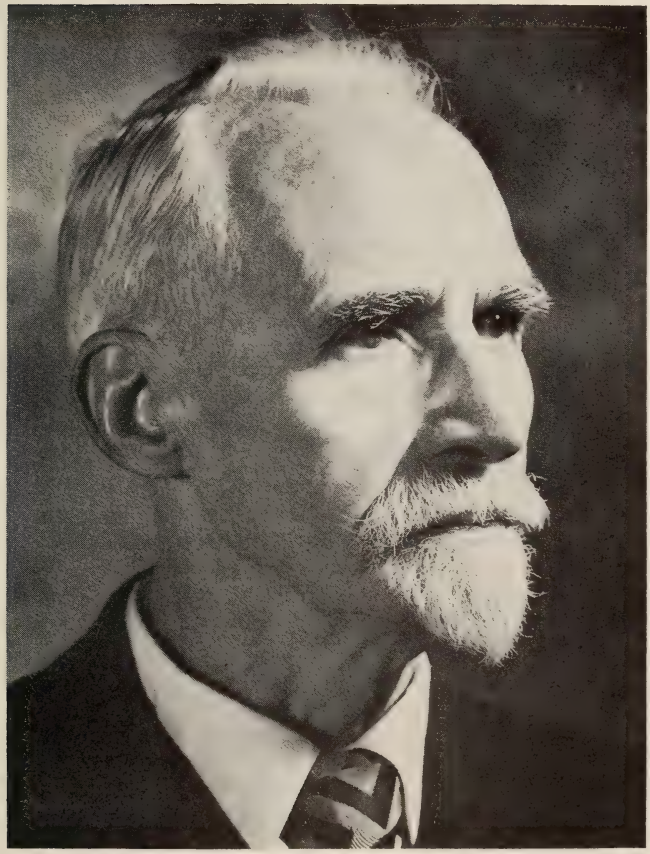
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OBITUARY



ANTONIE JOHANNES THEODORUS JANSE
1877–1970

On June 12th, 1970, at the age of ninety-three, Dr. A. J. T. Janse, a great Lepidopterist and a man of remarkable learning and ability, passed away. For almost seventy years he collected, reared, studied, and described Lepidoptera, a privilege given to very few. All by himself, he built up a unique collection of the Heterocera of southern Africa.

Dr. Janse was born in The Hague, the Netherlands, where he received his education. He emigrated to South Africa in 1899, and became a teacher in Waterval (Nuwe Smitsdorp). He started his entomological work under the most primitive conditions, but his boundless enthusiasm enabled him to overcome these difficulties and his painstaking ceaseless collecting laid the foundation for all his far-reaching scientific work of later years. In the early days he did his collecting on foot, later by donkey cart. His was pioneer work, for at that time there was no extensive collection of Lepidoptera in South Africa.

In 1905 he accepted the post of lecturer at the Transvaal Normal College, and this marked the turning-point in his early career, since it enabled him to take up entomology in earnest and to become a scientist. The facilities available to him in Pretoria made it possible for him to undertake systematic research.

In 1921–1922 he visited Europe and worked at the museums in London, Leiden and Berlin, comparing and identifying many hundreds of specimens from his collection. In recognition of his work he was presented in London with the Joicey collection of Pyralidae, which he brought back to Pretoria.

After his return, Janse was appointed honorary professor of Systematic Entomology at the Transvaal University College. He held this post until his retirement in 1937. In 1925 the University of South Africa awarded him the *honoris causa* degree of Doctor of Science.

The most rewarding acknowledgment of Janse's entomological achievements came in 1945, when the South African Government bought his collection, library, and equipment, and placed them in the care of the Transvaal Museum, he himself being appointed Honorary Curator of Heterocera. However, because the museum had no space to house Janse's collection, it was decided to leave it at his house, where his laboratory was also located, and to transfer the museum's collection of Heterocera there instead, thus uniting the two collections. The Government's action was of vital importance for the future of Janse's life work, which was now secure; the museum provided the necessary funds to buy urgently needed drawers and other equipment. An assistant was appointed to continue his work eventually. In 1953 space became available for the collection at the museum, but Janse continued to work in his laboratory, using material on loan from the main collection.

During the greater part of his life Janse had to do all his entomological work during holidays and in his spare time. Nevertheless, he found time to publish a substantial series of papers, and in 1932 began on his outstanding series "The Moths of South Africa." But it was not until his retirement a few years later that he was able to give his full attention to the publication of this valuable series. Up to the time of his death he had published over forty papers and eight large volumes of the Moths series. He described more than five hundred new species, for which he also prepared detailed drawings of external structures and genitalia of both sexes. He always maintained that such drawings should be made a compulsory part of any description of new taxa.

Before his death, Janse had completed the manuscript for the next volume of "The Moths of South Africa" and had almost finished another volume on the types of South African Microlepidoptera described by the late E. Meyrick.

During his association with the Transvaal Museum, Janse made three extensive collecting trips by motor car and trailer; although he was already over seventy-five, he travelled with his wife as his only assistant. He continued his research with unflagging zeal through the years, until at last a serious illness put an end to his activities about a year before his death.

Janse's frequent letters were always striking and written in a firm hand; a year ago he wrote "so long my hand and eyes are still good, can the work go on." These letters breathed such vitality, enthusiasm, and trust in his work that they conveyed something fresh, simple, and deeply encouraging, especially when one remembered the writer's age.

Only a few are blessed with such a wealth of enthusiasm for their work. Few can

devote themselves to it so wholeheartedly. Add to this unusual stamina and insight, and one has the stuff of which Janse's great generation of Lepidopterists was made. His must have been an enviable, full, and happy life.

L. Vári, *Transvaal Museum, Pretoria, South Africa and* A. Diakonoff, *Leiden Museum, The Netherlands.*

PRELIMINARY NOTES ON THE BUTTERFLIES OF ROOSEVELT COUNTY, NEW MEXICO

Roosevelt County is situated on the central eastern border of New Mexico, in the southern portions of the Great Plains. Its primary industry is agriculture, but despite this, it has one of the most interesting butterfly faunas of the state.

I have been able to make only four trips to this area, two in 1965 and two in 1966. As a result of these four trips, I have recorded 38 species, plus two more seen. One other is recorded from the county; *Megathymus coloradensis elidaensis* Stallings, Turner, and Stallings, the type locality of which is located southwest of Elida. Of the thirty-eight species of which I have specimens, four have not been taken by me from anywhere else in the state. Of the remaining thirty-four, twelve are represented by four records or less in the state. One of the species seen but not taken was a battered specimen of *Papilio cresphontes* Cramer, a species which has also never been recorded elsewhere in the state to my knowledge.

The main locality in which I have collected is located six miles west of Portales, along New Mexico Highway 88. This is an extremely unattractive place for the Lepidopterist, being situated at the junction of four farm fields, two to the north of the highway and two to the south. On the south side of the road, there is a short row of elm trees. The tallest of these is about 25 feet high. It was on one of these elms that a larva of *Polygonia interrogationis* (Fabricius) was collected. The larva unfortunately died later, but there is little doubt as to its identity. One adult was also seen, but escaped capture. The only other record the author has of this species in New Mexico is at his home in Albuquerque.

The majority of the butterflies were collected at roadside flowers, which are especially numerous in the fall. The area between the edge of the fields and the road is quite wide (at least 75 feet), so there is a large patch of them.

Following is a list of the thirty-eight species collected at this locality on September 12, 1965; September 18–19, 1965; June 2–3, 1966, and June 11, 1966. Known state records are marked with an (*) and unusual records are marked with an (!).

Hesperiidae

*1. *Lerodea eufala* (Edwards); Sept. 19, (2 males).
!2. *Amblyscirtes eos* (Edwards); June 3, (1 male).
3. *Atalopedes campestris* (Boisduval); Sept. 19, (1 male, 1 female); June 2, (1 female).
4. *Hesperia uncas uncas* (Edwards); Sept. 19, (1 female); June 2, (11); June 3, (17); June 11, (1).
!5. *Hylephila phyleus* (Drury); June 2, (1).
6. *Pholisora catullus* (Fabricius); Sept. 12, (1); Sept. 19, (1); June 3, (2); June 11, (11).
7. *Pyrgus communis* (Grote); Sept. 12, (1); Sept. 18, (1); June 2, (1); June 3, (4); June 11, (1).

Papilionidae

!8. *Battus philenor philenor* (Linnaeus); June 3, (1); June 11, (1).
9. *Papilio polyxenes asterius* Stoll; June 3, (5); June 11, (2).

Pieridae

10. *Pieris protodice* Boisduval & Le Conte; Sept. 19, (2 males); June 3, (2).
11. *Colias eurytheme* Boisduval; Sept. 12, (1 male, 1 female); Sept. 19, (2 males, 5 females, 3 female *alba*); June 3, (1); June 11, (6).
12. *Phoebis sennae eubule* (Linnaeus); June 11, (1 male).
!13. *Kricogonia lyside* (Godart); June 3, (1 male, 5 females).
!14. *Eurema mexicana* (Boisduval); Sept. 19, (1 male).
*15. *Eurema lisa* Boisduval & Le Conte; Sept. 12, (2); Sept. 19, (3 females).
16. *Eurema nicippe* (Cramer); Sept. 19, (2); June 3, (6); June 11, (1).
17. *Nathalis iole* Boisduval; Sept. 12, (2); Sept. 19, (6); June 2, (1); June 3, (1); June 11, (1).

Lycaenidae

18. *Strymon melinus franki* Field; Sept. 19, (2); June 2, (7); June 3, (8); June 11, (6).
19. *Brephidium exilis* (Boisduval); Sept. 19, (1).
20. *Leptotes marina* (Reakirt); June 2, (2); June 3, (3).
21. *Hemiargus isola alce* (Edwards); Sept. 12, (2); Sept. 19, (2); June 2, (5); June 3, (5).
22. *Plebejus acmon lutzi* dos Passos; June 3, (2).

Libytheidae

23. *Libytheana bachmanii* (Kirtland); June 3, (1).
It is not known whether this specimen is *larvata* (Strecker) or typical *bachmanii*. I have been unable to locate the specimen.

Nymphalidae

!24. *Anaea andria* Scudder; Sept. 12, (1); Sept. 18, (3).
*25. *Mestra amymone* (Menetries); Sept. 12, (1).
Four other specimens were seen on this date, but unfortunately I was *sans* net. See Masters, (1970).
26. *Vanessa atalanta* (Linnaeus); Sept. 19, (1); June 11, (4).
27. *Vanessa virginiensis* (Drury); June 11, (8).
28. *Vanessa cardui* (Linnaeus); Sept. 18, (1); June 3, (3); June 11, (2).
29. *Nymphalis antiopa* (Linnaeus); Sept. 18, (1); Sept. 19, (1).
!30. *Chlosyne lacinia adjutrix* Scudder; Sept. 12, (5); Sept. 18, (1); Sept. 19, (11); June 3, (1).
!31. *Phyciodes texana texana* (Edwards); June 2, (1).
*32. *Phyciodes phaon* (Edwards); Sept. 19, (1 male, 1 female).
!33. *Phyciodes picta canace* Edwards; Sept. 12, (1); Sept. 19, (1); June 2, (2); June 3, (4).
!34. *Phyciodes vesta* (Edwards); June 3, (1).
!35. *Texola elada ulrica* (Edwards); June 3, (1).
36. *Euptoieta claudia* (Cramer); Sept. 19, (1); June 2, (1); June 3, (2); June 11, (1).
!37. *Agraulis vanillae incarnata* (Riley); June 3, (1); June 11, (2).

Danaidae

38. *Danaus gilippus strigosus* (Bates); June 3, (4).

MICHAEL E. TOLIVER, *1612 Indiana NE, Albuquerque, New Mexico.*

OBITUARY



JOHN ADAMS COMSTOCK
Jan. 30, 1883–Dec. 26, 1970

Entomologists will learn with regret of the death, on December 26, 1970, of Dr. John Adams Comstock, at his home in Del Mar, California. Past President and Honorary Life Member of the Lepidopterists' Society, he would have been 88 years old on Jan. 30, 1971.

His interest in Lepidoptera started at a very early age and continued throughout his long and very productive life. He published over 220 papers in various journals, and he wrote and published *The Butterflies of California.*

A complete biography and bibliography will be published in the 25th anniversary publication of the Lepidopterists' Society in 1972.

LLOYD M. MARTIN, *19 Meadow Lane, Route 1, Prescott, Arizona.*

FOREST-PRAIRIE TRANSITIONS AND THE ADMIXTURE OF BUTTERFLY FAUNAS

KURT JOHNSON[1]

Terms referring to general types of ecological communities, such as *forest, prairie, tundra,* or *montane* communities, are used by ecologists to describe or categorize the character of environments. Likewise, they are used in description of types of species inhabiting such areas. Terms such as *prairie butterfly,* or *forest butterfly,* though sometimes vague in meaning, are common descriptive terms in Lepidopterology.

Transitions from prairie communities to forest communities differ in degree of abruptness from place to place. The escarpment affords a wide area of interspersement of these types of communities, while an abruptly rising mountain range may leave only a small amount of margin between forest and grassland. It seems obvious that the degree of interspersement of forest and prairie has a counterpart in the extent of *forest, prairie,* or *forest-prairie* types of species making up an area's faunal admixture.

Recent studies of butterfly faunas in escarpments along the western edges of the Great Plains, where forested areas are interspersed with prairie (Johnson and Nixon, 1967; Johnson, 1971) suggest extensive sympatry of butterfly species from various type of ecological communities. Hence, an investigation into the effect of forest-prairie interspersement on faunal admixtures seemed invited.

I therefore created a scheme by which types of species indicating the forest, prairie, or forest-prairie ecology might be designated and their percentage composition in various faunas analyzed.

Materials and Methods

It was deemed important to conduct the study in areas representing intergradations between two extremes. Hence, I selected the Bighorn Mountains of Wyoming (an area where transition from grassland to forest is abrupt), the scantily forested escarpments of the Long Pine Recreation Area in north-central Nebraska, and several areas between them. The latter included the Laramie Mountains of Wyoming, the Front Range of Colorado, the Black Hills of South Dakota, the Pine Ridge of Nebraska, and the escarpments along the Niobrara River cuttage in Nebraska. The location of these study areas is presented in Figure 1. Since nearly all of these areas have had recent specific faunal studies, a list of species for each area was conveniently obtained within the criteria cited concerning

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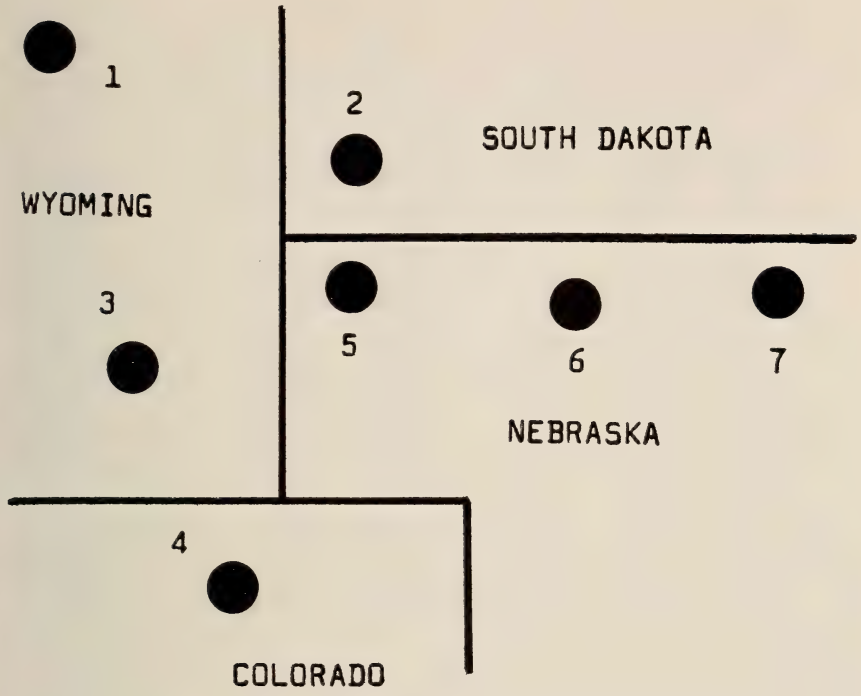


Fig. 1. Locations of the seven study areas. 1, Bighorn Mountains; 2, Black Hills; 3, Laramie Mountains; 4, Front Range; 5, Pine Ridge; 6, Niobrara River cuttage; 7, Long Pine Recreation Area.

them. Because the faunas of these separate areas are not unknown to lepidopterists and because the lists were compiled from a variety of sources, it was not deemed important to the study to include them, except to note that the species were organized according to dos Passos (1964). The number of species in each fauna is listed below each column on the dendrogram. The sources of the faunal lists are summarized below.

The faunal list of the Pine Ridge in Nebraska came from Johnson and Nixon (1967). That of the Niobrara River cuttage and Long Pine Recreation Area from Johnson's *The Butterflies of Nebraska* (1971). The Wyoming lists were obtained from the literature (DeFoliart, 1956; Nabokov, 1953) and the extensive personal research of Richard Hardesty (Douglas, Wyoming) and John S. Nordin (Webster, South Dakota). Hardesty and Nordin also assisted in compiling the faunal list of the Black Hills of South Dakota. The Colorado list was culled from county records in Brown (1957).

Since it is difficult to construct an exact criterion to designate which

species are found "within" any physiographic area, a consistent decision was made to define mountain areas as all parts which rose above the lowlands, that is, having a higher elevation than the surrounding plains. Similarly, regarding river cuttages, this criterion included all areas below the surrounding plains, and in escarpment situations, that transition between surrounding lowlands and table lands above. Although criteria of this type cannot be completely exact, the amount of variation within the definitions seem not too dangerous, since it leaves the amount of general interspersement of forest and prairie dependent on the abruptness of the transition between dominance of forest or prairie. In this study these criteria grouped the study areas into three general categories: escarpments, with complete interspersement (Pine Ridge, Niobrara cuttage, Long Pine Rec. Ar.), areas of moderate transition (Black Hills, Front Range, Laramie Mts.) and an area of abrupt transition (Bighorn Mts.). That the abruptness of transition affects consistently the types of species present is the important thesis of this investigation.

The second problem was developing definitions for *forest* butterfly, *prairie* butterfly, and *forest-prairie* butterfly. It was most important that the technique be clear and as unbiased as possible. To satisfy this, Mr. Hardesty and I separately gave each species one of three labels: forest, prairie, or forest-prairie. The criteria used were based upon questions: "Must one go to the forest (or prairie, or either) to find the species?" and if this could not be definitive, "In what environ does the foodplant grow?" The success of this method is evident since Hardesty and I disagreed on the designation in only a few cases. In these I made the redesignation on the grounds of further consideration of the original criteria. With lists of all the resident Papilionoidea defined into these three categories for each study area, the percentage of each category in each fauna was computed. Results are summarized in Figure 2, which presents dendrograms of the percentage composition of each fauna.

To facilitate the accuracy of sampling, the Hesperiidae were omitted since they are poorly known in some of the collection areas. It should be noted, however, that this omission tends to depress the percentage of prairie species in the admixture since many of the skippers are of that type. Also omitted were any tundra forms inhabiting a study area. The use of general categories like *forest* or *prairie* as defined in this study seems to allow for this. To give the Colorado list a realistic "Front Range" integrity, the list from that area was limited to Larimer and Boulder Counties. Also, nowhere were the faunal resemblances *between* the faunas involved (these are calculable after Long, 1963), nor was the type of forest (deciduous or coniferous) designated.

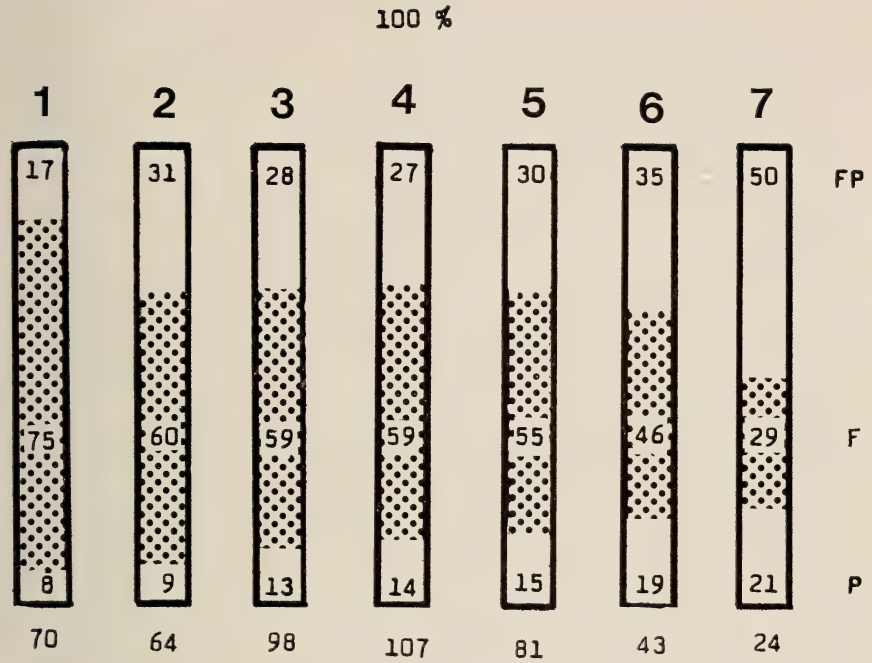


Fig. 2. Graphic representation of faunal admixture in each study area. Forest-prairie taxa (FP) illustrated above, clear; Forest taxa (F) represented in middle, stipled; Prairie taxa (P) represented below, clear. 1, Bighorn Mountains; 2, Black Hills; 3, Laramie Mountains; 4, Front Range; 5, Pine Ridge; 6, Niobrara River cuttage; 7, Long Pine Recreation Area.

Figures below each bar represent number of species in each fauna.

Results

The results are summarized in Figure 2. Each bar of the graph is arranged to illustrate change in number of prairie taxa (below, clear), forest-prairie taxa (above, clear), and forest taxa (middle bar, stipled).

The order of the graphs corresponds with the degree of transition ecologically proceeding from the most abrupt (Bighorn Mts., 1) to the most gradual (the Long Pine Rec. Ar., 7). Note that both the Front Range sample and Laramie Mountains sample are represented though they reflect no real difference in abruptness. This serves to illustrate similarity in types of admixture in two very similar ecological situations.

The portions of each graph representing percentages of species indicating certain types of ecological situations show a consistent pattern relative to the abruptness of the ecological transition from prairie to forest. The general correlations are as follows:

Increase in abruptness, corresponding with less interspersement of prairie and forest, results in:

1. increase in forest indicative species
2. decrease in prairie indicative species
3. decrease in forest-prairie indicative species

Decrease in abruptness, corresponding with more interspersement of prairie and forest, has the opposite result in all cases.

Consistent with the general ecological concept that ecotones often harbor a major portion of the species of biota in an area, results indicate that the complete interspersement of forest and prairie biomes in the escarpments promotes a dominance of those areas by forest-prairie types of species (see Long Pine Rec. Ar., 7). In fact, with decrease in abruptness of transition the amount of forest-prairie species increases at a greater rate than purely prairie taxa, indicating the pressure of the marginal ecology on the faunal admixture. Discussion of the relative roles of prairie and forest in the margin is very difficult, but it appears that the factor of forest may dominate an area. This is illustrated by the fact that even a semblance of woodland, such as the scattered stands of trees in the Long Pine area affords large numbers of forest species a habitat, probably by its affording the general flora of the area a divergence. This conforms to the observation that food-plant diversity in the forest and especially in the ecotonal areas is usually greater than on the surrounding mixed-prairie. The role of the Pine Ridge forests in influencing the admixture of the Nebraska butterfly fauna (Johnson, 1971) is an example of this on a large scale. The relationship of types of species and the habitats they utilize invites new thinking into problems of taxonomic and distributional evolution.

Conclusions

The study illustrates that when types of species indicating certain ecological conditions are designated realistically, their percent admixture in a fauna varies consistently with degrees of spatial transition in an areas ecology.

Though the general assumption is simple, the analysis of it seems justified since the assumption is usually made without any thought to the parameters or criteria for its having meaning.

Hence, an effort was made to give definition to categories that are usually general or non-definitive. The paper points out that such a definitive study can be made, and hopefully offers criteria on which similar questions can be investigated.

Acknowledgments

I am grateful to Dr. C. A. Long (Wisconsin State University, Stevens Point) for his suggestions concerning the project, and to Mr. Richard Hardesty (Douglas, Wyoming) and Dr. John S. Nordin (Webster, South Dakota) for their aid in compiling the faunal lists.

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BOOK REVIEW

MOTHS AND HOW TO REAR THEM, by Paul Villiard. 1969, 242 pp. + i–xiii, profusely illustrated with half tones. Funk and Wagnalls, 380 Madison Avenue, New York. Price $10.00 U.S.

This is a volume that everyone interested in rearing the larger moths, particularly the sphingids and saturniids, should have on his reference shelf. One hundred and seventy-seven species are discussed under the headings of family [name], popular name, range, availability, preferred foodplant, diapause [stage], ova, larvae, rearing requirements, cocoon and adult. The adult, the mature larva, the cocoon or pupa, and usually the egg of each of the native and exotic species discussed are illustrated in half-tone reproduction.

Although an introductory section is devoted to a detailed description of the spreading procedure, some of the adults illustrated have not been spread with any great skill and many of these appear to have become wet and matted at some stage. The author-photographer seems to have a penchant for dark backgrounds in his illustrations and in the case of dark specimens or those with translucent wings results are not pleasing. The usage of generic names is often not current but this causes no difficulty.

The book is a highly enjoyable one and I thoroughly recommend it to all interested in the natural histories of the larger moths.

D. F. HARDWICK, *Editor.*

UNUSUAL BUTTERFLIES IN NORTHERN PENNSYLVANIA

Following a few years' collecting as a boy in Tioga County, Pennsylvania in the mid 1920s, I again began to take an amateur interest in butterflies about ten years ago.

The rewakening of active interest really began when I discovered a colony of larvae of *Battus philenor* on a Dutchmans Pipe Vine (*Aristolochia macrophylla*) at my home in Wellsboro in late July 1959. This common southern butterfly is rare in northern Pennsylvania so the larvae were cared for until the adults emerged in late August. No other wild larvae or adults have been seen here since.

On May 15, 1960, I caught a single *Pieris virginiensis* while I was on a hiking trip in an open mixed hardwood forest about 8 miles southeast of Wellsboro. This led to an active search and since that time a number of colonies of varying sizes have been located in the area.

On July 6, 1963, while exploring an acid bog for orchids and other plants (*Polygonia ophioglossoides, Calopogon pulchellus, Sarracenia purpurea, Drosea rotundifolia, Menyanthes frifoliata* and *Vaccinum macrocarpon* are present) about thirty miles southwest of Wellsboro, I noted a small blue-gray butterfly which proved to be *Lycaena epixanthe*. In a mountain-top meadow near this bog, Arthur Shapiro scored a first for the area by netting a male *Colias interior* on July 11, 1968.

On May 19, 1968, while I was walking along a grassy woods road, about eight miles southeast of Wellsboro, in an area now grown up to mixed hardwood brush, a fresh female *Erora laeta* literally dropped into the road in front of me. Later that same year, on July 29th, a worn male was collected and another sighted on blossoming hardhack (*Spirea tomentosa*) in a nearby wet field.

Last season (1970) on June 25th, July 1st and July 5th, in two locations about twenty miles apart north and west of Wellsboro respectively, I collected a total of ten *Thymelicus lineola,* all males. These insects were feeding on the blossoms of common milkweed (*Asclepias syriaca*) but were very wary and difficult to approach. No females have been collected.

A number of large colonies of *Chlosyne harrisii liggetti* Avinoff occur here, flying from early June to early July.

The Tioga-Potter-Lycoming County area in north-central Pennsylvania can be classified as Transitional Zone with tendencies toward Canadian Zone in the higher elevations. Mountains are rounded with maximum elevations of approximately 2200′. Valley bottoms are about 1300′ elevation. It is mostly heavily forested with second-growth hardwoods, principally maples, beech, cherry, ash, basswood and some oaks. There are scattered hemlocks and some red and white pine.

The presence of the *L. expixanthe* acid bog can possibly be attributed to pre-glacial times and the peculiar geological history of the area. Geologists agree that the edge of the last glacier was nearby and that previous to that time the region drained northward into the St. Lawrence River. The glacier halted this flow, however, and an entire new drainage system developed. A new water passage was cut through the then existing mountain barrier to the south forming what is now known as "Pennsylvania's Grand Canyon," a steep-sided gorge about fifty miles long and one thousand feet deep, draining into the Susquehanna River and thence into the Atlantic Ocean at Chesapeake Bay. In Potter County, about forty miles west of Wellsboro, there is now a three-way watershed, with drainage dividing into flowages to the north (St. Lawrence River), to the southwest (Mississippi River), and to the southeast (Susquehanna River).

GEORGE F. PATTERSON, *Wellsboro, Penn.*

NOTICE TO CONTRIBUTORS

Contributions to the *Journal* may deal with any aspect of the collection and study of Lepidoptera. Shorter articles are favored, and authors will be requested to pay for material in excess of 20 printed pages, at the rate of $17.50 per page. Address all correspondence relating to the *Journal* to: Dr. D. F. Hardwick, K. W. Neatby Bldg., Central Experimental Farm, Carling Ave., Ottawa, Canada.

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Literature cited: References in the text should be given as, Comstock (1927) or (Comstock 1933, 1940a, 1940b) and all must be listed alphabetically under the heading LITERATURE CITED, in the following format:

COMSTOCK, J. A. 1927. Butterflies of California. Los Angeles, Calif. 334 pp.
———— 1940a. Notes on the early stages of *Xanthothrix ranunculi*. Bull. So. Calif. Acad. Sci. 39: 198–199.

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Material not intended for permanent record, such as current events and notices, should be sent to the editor of the *News*: Dr. C. V. Covell, Dept. of Biology, University of Louisville, Louisville, Kentucky 40208.

Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA
by CYRIL F. DOS PASSOS

Price, postpaid: Society members—$4.50, others—$6.00; uncut, unbound signatures available for interleaving and private binding, same prices; hard cover bound, add $1.50. Revised lists of the Melitaeinae and Lycaenidae will be distributed to purchasers free.

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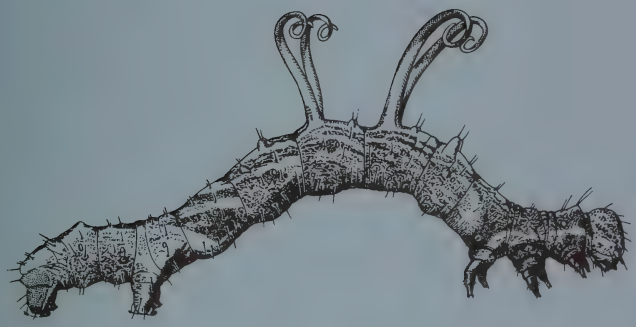
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NOTES ON GREGARIOUS ROOSTING IN TROPICAL BUTTERFLIES OF THE GENUS *MORPHO*

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Recent literature on general theories in community ecology has stressed the evolution of highly specialized patterns of behavior in species that inhabit tropical rain forests, (Margalef 1968; Miller 1969; Slobodkin and Sanders 1969). It is held that the stable (e.g., Levins 1968) or predictable nature (e.g., Levins and MacArthur 1967; Slobodkin and Sanders, 1969) of the physical environment in the tropics allows for organisms to cue in on the subtle features of the habitat, and adjust very well by developing very specialized and highly evolved patterns of behavior related to survivorship in low-density populations.

Clearly, studies of behavioral patterns associated with reproduction, survivorship, and daily activity patterns in natural populations of tropical organisms are needed to assess the generality of such theoretical considerations. This present paper summarizes observations on repeated gregarious nocturnal roosting in the tropical butterflies, *Morpho amathonte centralis* and *Morpho granadensis polybaptus* (Lepidoptera: Morphinae). The observed consistency and duration of this behavior in males of these large butterflies indicates that it may have selective value with respect to (1) efficient exploitation of food sources and (2) reservation of the bulk of daily energy budgets for courtship activities. With the recent exception of a discovery of this phenomenon in a supposedly tasteful nymphaline, *Marpesia bernia,* (Emmel and Benson 1971), gregarious nocturnal roosting habits were known mainly in distasteful species of tropical butterflies (e.g., Poulton 1930; Carpenter 1933; Crane 1955; 1957; Owen and Chanter 1969) with the adaptive value of such behavior being that the noxious or distasteful qualities of the butterflies *en masse* is a much more effective predator-deterring behavior than if individuals roosted singly

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(Crane 1955). The study of Emmel and Benson (1971) and the present paper suggests that different species of tropical butterflies, both distasteful and tasteful forms, have evolved such behavior as different adaptive strategies. Unlike the interpretation of such behavior in other butterflies (e.g., Emmel and Benson 1971), it is unlikely that gregarious roosting in *Morpho* butterflies acts as a mechanism against predatory attacks.

Observations

Four roosts of adult male *Morpho amathonte* were discovered during January and early February 1970 in a lowland tropical rain forest ("La Selva") located in northeastern Costa Rica. These discoveries were made in conjunction with observations on the feeding and flying activities of these butterflies, and these studies are summarized elsewhere (Young 1971a). All of the butterflies seen at each roost turned out to be those that had been marked previously at their daily feeding sites (natural accumulations of fallen fruits of the canopy tree, *Coumarouna* (= Diptyerx) *oleifera* (Papilionaceae—"Almendro"); the group of butterflies associated with a feeding site were the *same* individuals that roosted together during the night. There was no exchange of individuals among the widely-separated four feeding sites studied and observations were made to determine the extent of roost faithfulness, in addition to survivorship and recruitment rates. At the time of discovery of these roosts, they consisted of 5, 2, 2 and 5 individuals (with the order being roosts 1, 2, 3 and 4 to correspond with feeding sites 1, 2, 3 and 4 discussed in Young 1971a).

One roost of adult male *Morpho granadensis* was discovered during May 1970 in the montane tropical rain forest located near Cuesta Angel in central Costa Rica. This roost initially consisted of 14 individuals and over a 10-day period, all of these butterflies were marked in order to determine roost faithfulness, survivorship, and recruitment rates. Unlike *Morpho amathonte,* these individuals were not marked at their feeding sites since these were not known. However, at La Selva, a few individuals of this species were seen roosting with *Morpho amathonte* and these butterflies were also observed. Marking was facilitated in this species as they were easily netted after 5 PM (CST). In both species, an enamel base paint, "Flo-Paque," was used to mark butterflies; each butterfly was given 2 distinct markings on the undersides of the wings: one mark to denote roosting site, and another mark to denote individual number.

The four roosts of *Morpho amathonte* were observed for five consecutive months, with observations being made on several days per month. The roost of *Morpho granadensis* was observed for 3.5 months and not as frequently as those of *Morpho amathonte.* At the time of marking, the wing condition of individuals (tattering, loss of scales, fading) was noted in

order to study changes in the age-structure of the adult population; sex was also determined. The latter was easily done since males are much brighter and possess different markings than females, and thus sexes could be distinguished at a distance.

In the case of *Morpho amathonte*, all four roosts were situated in low, open, secondary-growth vegetation encompassed by closed-canopy forest. These roosting sites were very close to feeding sites and typically no more than 35 meters away. Adults usually roosted on the upper surfaces of large-sized leaves of various plant species, and in vertical positions. Wings were always kept tightly closed while roosting, and against the background of dark green foliage and shadows, the butterflies were difficult to see even at close distances. Adults were widely spaced with the nearest distance between two individuals being a few feet. It was never seen that more than one adult rested on a leaf; perhaps in this respect roosts of *Morpho* butterflies are structurally different than those of other species. Emmel and Benson (1971) report on the occurrence of several individuals of *Marpesia bernia* roosting together on the undersides of a leaf. Undoubtedly size of the insect is an important factor in determining the relative proximity of individuals in a roost; *Morpho* butterflies are very large (average wingspan 25.5 cm in both species) and perhaps require more space on a per individual basis. Furthermore, adult males are aggressive along their flight paths (Young 1971a) and this may be an important factor in determining the distances among roosting individuals. Aggressive interactions among males at roosting sites have not been observed.

The roost of adult male *Morpho granadensis* was located on branches of trees that were overhanging a river (Rio Sarapiqui) and individuals hanged from the upper surfaces of leaves. Whereas the roosts of *Morpho amathonte* took on a more circular configuration due to the shape of the openings in the forest used, the roost of *Morpho granadensis* was oblong in shape in that it extended along the river bank and included various species of trees. However, individuals were again widely-separated. Individuals roosted about 1.5 meters above the water and in the case of *Morpho amathonte*, individuals roosted from 2 to 5 meters above the ground. In two of the roosts of *Morpho amathonte*, individuals of *Morpho granadensis* were seen over long periods of time. At one roost (roost 2) there were 3 individuals of *Morpho granadensis*, and at a second roost (roost 4) there were 2 individuals. Like the Cuesta Angel roost, all of these individuals were males.

A summary of the temporal patterns of roost occupancy are given in Table 1. As seen for adult aggregations at feeding sites (Young 1971a), there was virtually no turnover in adult males of *Morpho amathonte* at

TABLE 1. Evidence for high roost faithfulness[a] in adult *Morpho* butterflies in Costa Rican tropical rain forests.

Months	N[b]	Locality	Roost No.	Number[c] of Butterflies		
				Females	Males	Total
			Morpho amathonte			
Feb.	14	La Selva	1	0	5	5
Mar.	20			0	5	5
Apr.	18			0	6	6
May	22			0	6	6
June[d]	5			0	5	5
Feb.	14	La Selva	2	0	2	2
Mar.	20			0	2	2
Apr.	15			0	3	3
May	20			0	3	3
June[d]	6			0	2	2
Feb.	14	La Selva	3	0	2	2
Mar.	18			0	2	2
Apr.	17			0	2	2
May	19			0	2	2
June[d]	5			0	2	2
Feb.	13	La Selva	4	0	5	5
Mar.	20			0	5	5
Apr.	18			0	6	6
May	20			0	6	6
June[d]	5			0	5	5
			Morpho granadensis			
Apr.	8	Cuesta Angel	1	0	14	14
May	11			2	16[e]	18
June	17			0	10	10
July[d]	8			1	13[e]	14

[a] Defined here as the continuous occupancy of the same roosting site(s) over a long period of time (several months).
[b] N is the number of days of observation at roots each month.
[c] These are means; standard errors were very small and are not included in the table.
[d] For *Morpho amathonte*, there was only one week of observation during early June; for *Morpho granadensis*, there was only 8 days of observation during early July.
[e] Increments in adults numbers was due to appearances of newly-emerged males at the roost.

their nocturnal roosts. Turnover was more prevalent with *Morpho granadensis* (Table 1).

The time of departure and arrival of the butterflies at the roosts each day was highly variable and depended upon local weather conditions. This was particularly true for *Morpho granadensis*. On overcast afternoons, individuals arrived usually between 4–6 PM, whereas on sunny afternoons, arrival was usually restricted to 5:30 to 6:15 PM. It is of interest to describe the pattern of arrival of individuals at the Cuesta Angel roost of *Morpho granadensis*. The roost was located along a river bank at

the base of a steep gorge covered with closed-canopy tropical rain forest. Standing on the opposite of the river and directly in front of the roost site, with the aid of binoculars, the pattern of arrival could easily be observed for these very large and conspicuous butterflies. On all days of observation (a total of 54), the arrival pattern was the same and fascinating: one by one, and following each other at very close intervals, the butterflies would lazily fly down to the roost from the upper reaches of the gorge. They formed an imaginary line of blue objects as they flew down the gorge over the tops of the trees. They always approached the roost from one side and several meters away; then they would fly along the river bank until they reached the roost. On a sunny day, all individuals were in the roost within 25 minutes; the time involved was longer on overcast days but the pattern was the same. By being stationed very close to the roost, it was possible to observe the actual order (of marked individuals) of arrivals; this pattern was highly variable each day. Departure occurred usually between 8:30–9:30 AM each day and individuals flew off in different directions. In *Morpho amathonte,* arrival was staggered and individuals flew in from different directions. Departure was of a similar pattern and the roosts were usually vacated by 7:00 AM each day. No consistent order of arrival and departure for the marked individuals of this species could be determined. Young (1971a) suggests that adult males of this species elect to roost overnight in open, exposed areas in the forest so that they may receive the early sun ray to assist their bodies becoming sufficiently warmed-up for flight. This in turn, is related to the diurnal activity pattern of this species: adult males feed from 7–8:30 AM, fly on consistent flight paths from about 8:30 AM to 11:30 AM, and either partake in courtship activity along flight paths beyond this hour or rest near feeding sites before moving to nocturnal roosts between 5:00 and 6:00 PM (Young 1971a). Under such a diurnal activity pattern, it is expected that arrivals at roosts would be inconsistent, depending upon whether individuals were involved in courtship or resting near feeding sites.

On the other hand, both adult male and females of *Morpho granadensis* concentrate the bulk of their feeding activity to the late afternoon hours (3:00–6:00 PM) and presumably engage in courtship activity earlier in the day (Young 1971b). Like *Morpho amathonte,* adults of *Morpho granadensis* aggregate at feeding sites (at La Selva, these can be the same ones used by *Morpho amathonte*) (Young 1971b). The cessation of feeding with advancing nightfall or undesirable weather conditions may account for the "group return" pattern of arrivals to roosts in this species; since all individuals are involved in the same activity and at the same time, it is expected that they would be more consistent in arriving at roosts.

While it is clear that there is no movement of individuals once they are

settled in roosts, if a roost is approached (by human observer) to within about 2 meters of a resting individual, that individual will fly away for a short distance. When the disturbance is stopped, the butterfly will return to its original perch usually within 15 minutes. Depending on the direction of flight upon disturbance, an individual can either cause other resting individuals to fly or else there is no effect at all on other members of the roost. When branches were marked with small pieces of brightly-colored tape, it was discovered that individual butterflies in a roost almost always return to the same tree each day for nocturnal roosting. Such specificity for a given roosting site may imply the use of scent that is laid down and reinforced on subsequent visits. The problem, however, is very complex since individuals in a small area can single out their own roosting spots on different days. Wilson (1968) and Regnier and Law (1968) state that it is quite possible for different individuals of a species to possess individual-specific pheromones, resulting from subtle genetic differences, diet differences or other factors in the environment. Chain-reaction effects, in which one disturbed individual could initiate flight activity in other individuals were generally uncommon, although they occasionally occur. Unlike other known cases of roosting butterflies (e.g., Emmel and Benson 1971; Clench 1970), due to the relatively large distances among members of a roost in *Morpho*, it is unlikely that mass flight can result from disturbance directed to a single individual.

Discussion

Adult male butterflies of *Morpho amathonte* and *Morpho granadensis* form sleeping roosts of low densities in tropical rain forests. The low densities of members in these roosts is related to the adult population structure in these butterflies; adult male populations of *Morpho amathonte* are very small and individuals maintain the same individual-specific flight paths in the habitat. This is probably true for adult *Morpho granadensis*. Aggressive interactions occur along these flight paths and courtship behavior has also been observed on them (Young 1971a), and it is suspected that these flight paths function as territories. Flight paths radiate out from feeding sites, accumulations of decaying odorous fruit on the forest floor. Males from roosting aggregations very close to where they feed and both feeding sites and roosting sites are maintained over long periods of time. When the feeding site becomes non-functional (with cessation of fruit-fall), the butterflies disappear and the roosting sites become unoccupied. It thus appears that in *Morpho amathonte*, the location and usage of a roosting site is dependent primarily upon location and usage of a feeding site. Less is known about the relation of feeding sites and roosting sites in *Morpho granadensis*, although roosts are apparently used for long

periods of time. Thus, rather than a roosting site being used throughout the lifespan of individual adult males, occupancy depends mainly on persistence of feeding sites. Adult *Morpho* butterflies have been estimated to live close to 9 months (Young 1971a) and the maximum period of exploitation of certain feeding sites (and thus roosting sites) is 5 months.

The high turnover of adult males in the roost of *Morpho granadensis* may be interpreted as the result of predation on adults counterbalanced by low, but continuous recruitment of newly-emerged adults. In populations of *Morpho amathonte,* there is very little recruitment of adults at feeding sites and there is virtually no mortality of adults from predation (Young 1971a); thus, numbers in roosts tend to remain the same.

Young (1971c) advances a novel hypothesis to account for the differential predation by birds on species of butterflies belonging to the genus *Morpho.* Under this hypothesis, the apparently high mortality of adults in *Morpho granadensis* from predation is explained by the lack of an effective predator-deterring behavior pattern that is very effective in adult male populations of *Morpho amathonte;* adults of the latter species are successful at escaping from avian predators by attracting them through marked changes in flight behavior and then frustrating them in relatively short time. That adult *Morpho* butterflies are tasteful to avian predators is shown by (1) the discovery of wing fragments (bearing beak-marks) of certain species (*Morpho granadensis* and *Morpho peleides*) on the forest floor, under bird perches, (2) observations of attempted attacks by birds in the field, and (3) records of larval food plants apparently exclude genera known to contain noxious compounds that make other species distasteful (Ehrlich and Raven 1965). Larvae of *Morpho peleides,* a species closely related to *Morpho granadensis* (both are in the *achilles* group), in El Salvador feed on leaves of *Machaerium riparium* in the Leguminoseae (Alberto Muyshondt, V. E. Rudd, personal communications); the Leguminoseae are not known for toxic or noxious compounds. Not only are the present observations a first record of gregarious roosting in *Morpho* butterflies, but it is apparently the second recorded case of a palatable species showing such behavior, as the report of Emmel and Benson (1971) constitutes the first record for a palatable nymphaline. It is well known that many species of palatable butterflies are readily taken as food by caged birds (e.g., Brower and Brower 1964), but less known is the relationship between palatability and gregarious behavior in tropical butterflies.

Low turnover of adults, in addition to being related to levels of predation, may be due to a very long developmental time in these butterflies; for an undetermined species of *Morpho* in El Salvador, the developmental time from egg to adult under natural conditions is over 2 months (Senor

Alberto Muyshondt, personal communication). One recent study (Young 1971d) indicated that several species of tropical butterflies belonging to various genera have very long developmental times. Long developmental time, low adult population density, and mortality (predation and parasitism) on both adults and immatures may account for the low turnover of adults in *Morpho* populations (Young 1971a).

The lack of adult females from the roosts of *Morpho* butterflies may be due to undesirable behavioral interactions with males that could occur there. For *Morpho amathonte,* it is known that females are relatively rare at feeding sites where males aggregate, and when they feed there, they do so when males are absent (Young 1971a). Less is known about the behavior of adult females of *Morpho granadensis.* Interactions between sexes do not occur at feeding sites nor at roosting sites in either species; in *Morpho amathonte,* courtship takes place along the flight paths of males (Young 1971a). Causal observations at La Selva suggest that adult females of *Morpho granadensis* sleep singly on understory vegetation in the forest; specific locations for sleeping females are highly variable and the same spot is used for only a few days. Adult females of both species are probably much more variable in their daily behavior than are males. Females must continually search for suitable oviposition sites and since they are probably very long-lived (since males are), they probably remain fecund throughout the bulk of adult life and this implies a continual search for oviposition sites. Such a characteristic of their biology, obviously not shared by males, may account for the lack of similar predictive behavior in them. Data on the spatial distribution of immatures and how it relates to the spatial distribution of larval food plants are needed in order to understand behavior of females in *Morpho* butterflies.

The absence of females from roosts of males may also be an indication of a behavioral mechanism that prevents sexual interactions to occur in places in the habitat where several males may be present at the same time. The absence of females from nocturnal roosts as well as from feeding sites of males may prevent severe aggressive interactions that would result in failure of females to be mated; courtship interactions would be more successful in aggressive species at places where the chance of multiple-male encounter would be low. However, such behavior implies that adult males must have a very effective patrol behavior pattern for females in such low density populations; this is apparently the case for at least *Morpho amathonte* (Young 1971a).

Independent of any gregarious property of roosting in tropical butterflies, protection to individual members of a roost may result from the positions of perching. For example, Emmel and Benson (1971) interpret the perching of roosting *Marpesia bernia,* a tropical nymphaline, on the

undersides of leaves as a means of shielding individuals from both rain and the view of potential avain predators. In the same species, roosting near the tips of branches may ensure protection against roaming, leaf-gleaning insectivorous predators such as ants. The roosting of *Morpho* butterflies with their wings tightly closed (showing the cryptic undersides) and in vertical positions on the upper surfaces of leaves and near the tips of branches may also give protection to individual butterflies from rain and predators. At the time of day when the butterflies arrive at their roosts, they are very difficult to see when resting (protection against birds), and their positions on the outer surfaces of hanging leaves gives them a lot of room to leap out when disturbed (e.g., upon approach of a leaf-gleaning predator). During heavy rains, I have witnessed various roosting individuals to go practically untouched by rain resulting largely from their vertical positions with the wings kept tightly closed.

The repeated occupancy of the same roosting site by the same individuals over long periods of time suggests that these butterflies have evolved an efficient means of becoming very familiar with a portion of their habitat—e.g., it is a form of predictable behavior which such specialized behavior is related to protection resulting from coordinated group activity is not clear. The lack of close proximity of roosting individuals at a given roost does not allow for any one individual to "warn" the remaining members of the aggregation of an approaching danger (predator), and thus it is very unlikely that gregarious roosting in *Morpho* butterflies provides some protection *to the group* from predation. Rather, it appears that this behavior is the result of the butterflies aggregating at their feeding sites, which are very close by (at least for *Morpho amathonte*). Field observations support the view that all individuals simultaneously present at a *feeding site* will fly away when a human observer walks through the area (Young 1971a), even though different individuals may be widely separated. At feeding sites, gregarious feeding of *Morpho* butterflies appears to act as a behavioral mechanism against predatory attacks by resulting in chain-reaction effects of butterflies flying away. Depending on the proximity and number of potential nocturnal roosting sites that provide exposure to morning sunlight, there is a reasonable probability that several or all adults (since numbers are generally low per feeding site) associated with a given feeding site will actually roost in the same open spot in the forest. And as pointed out for certain pierid butterflies (Clench 1970), the presence of one individual at a roost may attract others to it; such an attraction, in the case of *Morpho*, may involve both chemical stimuli and visual cues. Tethered live individuals or paper models can attract other living individuals (Young 1971a). It thus may be very efficient for all individuals associated with a given feeding site to select, independently

of each other, the closest suitable nocturnal roosting site, so that very little energy has to be expended in traveling to feeding sites. Such a strategy appears feasible for at least *Morpho amathonte*, since adult males of this species spend a great amount of energy patrolling well-defined flight paths in search for mates (Young 1971a) and since a great deal of time and energy is put into such reproductive activities, less energy is available to search for new feeding and new roosting sites on a short-term (e.g., day-to-day) basis. The exploitation of the same feeding sites and roosting sites on a daily basis allows adult males to partition the bulk of their energy supply into territorial flying in search of mates.

While similar data are lacking for the daily activity schedule of adult males of *Morpho granadensis*, it may be that similar behavior patterns are present; i.e., the bulk of energy supply is channeled into activities associated with reproduction and only minimal amounts are used in the selection of feeding and roosting sites.

Such strategies appear to be of great evolutionary and adaptive significance in tropical organisms since population density is generally low in species that comprise tropical rain forest communities (e.g., Margalef 1968) and under such conditions of low density, a premium is placed upon highly specialized behavioral patterns that ensure courtship encounters. Thus, rather than gregarious roosting in *Morpho* butterflies having selective value in terms of predation, a more likely hypothesis, based on the structure of the roosts and their relation to feeding sites, is that they are a part of the predictable and efficient overall behavior of these butterflies that allow for the bulk of the daily energy budget of males to be used for courtship encounters. The closer spatially that feeding sites and roosting sites are to one another, the less energy is required to fly between them. Nocturnal roosting at feeding sites is presumably undesirable in that these areas are usually well-shaded from morning sunlight; roosting in an area exposed to morning sunlight ensures early activation of the butterflies. For *Morpho amathonte*, this behavior ensures early arrival at feeding sites before territorial flying; for *Morpho granadensis*, although data are lacking, such behavior may ensure initiation of searches to seek mates, since the bulk of feeding in this species occurs during late afternoon hours and presumably the food intake on a given day is put into use the following morning with courtship activities.

Summary

Observations were made on gregarious, nocturnal roosting by adult males of the large, tropical butterflies, *Morpho amathonte centralis* and *Morpho granadensis polybaptus* at two different sites in Costa Rican tropical rain forests. Individuals of these species roost gregariously in that

several individuals sleep in the same open area in the forest, although they are close to one another. High fidelity to roost is indicated by occupance over long periods of time (several months) and turnover of adults is usually low. Interactions (e.g., aggressiveness) among males does not occur at roosting sites and females are rare. Although not entirely ruled out, it is difficult to conceive of such behavior in males of these butterflies as being a form of collective defense against predators. A more plausible explanation, based on data on daily activity schedule including feeding and flying activities for *Morpho amathonte*, is that such behavior is a by-product of the gregarious feeding in these butterflies since feeding sites are located very near roosting sites. As with roosting sites, there is high fidelity by adult males of *Morpho amathonte* for feeding sites. Independent of the gregarious aspect of this roosting behavior, the type of position that the butterflies use may give protection against heavy rain and predators.

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TWO MOSAIC GYNANDROMORPHS OF *AUTOMERIS IO* (SATURNIIDAE)

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The recognition of a gynandromorph in nature is an exceedingly rare event. Hessel (1964) described a bilateral gynandromorph of *Automeris io* Fabricius taken at Washington, Connecticut. He refers to the capture of bilateral gynandromorphs of *Eacles imperalis* Drury taken at Pottersville, N. J. (1962) and *Callosamia promethea* taken at Crown Point, Indiana (1962) as momentous events in light of the extensively collected Saturniidae. The appearance of two gynandromorphs in a single season is unusual, and the data provided by these specimens is extremely valuable in understanding gene action.

In most Lepidoptera the female is heterogametic. Doncaster (1914), Remington (1954), and others have shown the female to have either a pair of non-homologous sex chromosomes (ZW type) or that one chromosome will be lacking (ZO type). The male possesses a homologous pair (ZZ type).

In *A. io*. the northern populations are polymorphic; the basic color of

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the male is yellow, while the female is a soft, rosy brown. Thus, cells of the male with ZZ chromosomes are expressed as yellow, while those of the female with a ZO chromosome complement are rosy brown.

The gynandromorphs described by Hessel (1964) were bilateral, one side of the body male, the other female. This bilateral condition may have been caused by a loss of a Z chromosome in the first cell division of the fertilized egg, or by the development of a binucleate ovum. Such gynandromorphs develop disproportionately in size because the female cells are larger. Consequently the female side is slightly larger than its male counterpart. Secondary sex characteristics such as form of antenna and the abdominal claspers, are quite obvious.

The gynandromorphs described in this paper are not bilateral, but mosaic. They are the first to appear in over 10,000 pupae observed by this author. Probably the loss or addition of the Z chromosome occurred at a later state in cleavage causing a disproportionate distribution of cells with a ZO chromosome expression in gynandromorph no. 19–69. Gynandromorph no. 18–69 suggests another possibility that a ZO cell in its division failed to form a cell membrane separating into two ZO cells, leaving a ZZ cell which produced male characteristics.

Gynandromorph 19–69 is predominantly male (Figure 1). The head and antenna are male, the prothorax and mesothorax are composed of male and female cells, the metathorax is female. The abdomen is male with a light dispersion of female cells. The upper surface of the right forewing which is slightly longer than the left, is predominately female with patches of male cells. The right hind wing is male with a band of female cells along the anal margin. The eyespot on the right wing is 11 mm by 7 mm while the left wing eyespot is 9 mm by 7 mm. The difference in size of the eyespots is caused by the band of female cells on the right wing whereas the left eyespot is composed entirely of male cells. The forewing undersides are unique in that identical patterns exist on both wings. A thin band of female cells is found along the costal margin, with a wide band of male cells extending from the subcosta radial$_1$ area to the medial$_2$ vein. The remainder of the wing is female except a small patch of male cells on the outer margin of the anal 2 area.

The right hind wing underside is male except for a narrow band of female cells from the center of the anal 2 area to the inner margin. The left hind wing underside is female except for male cells extending from the base along the distance from the base toward the apex.

In specimen 19–69 male cells are in greater proportion than female cells suggesting that initially the zygote was ZZ but loss of a Z chromosome in one cell occurred early in the cell cleavage phase causing the female ZO expression in all future cells developing from it.

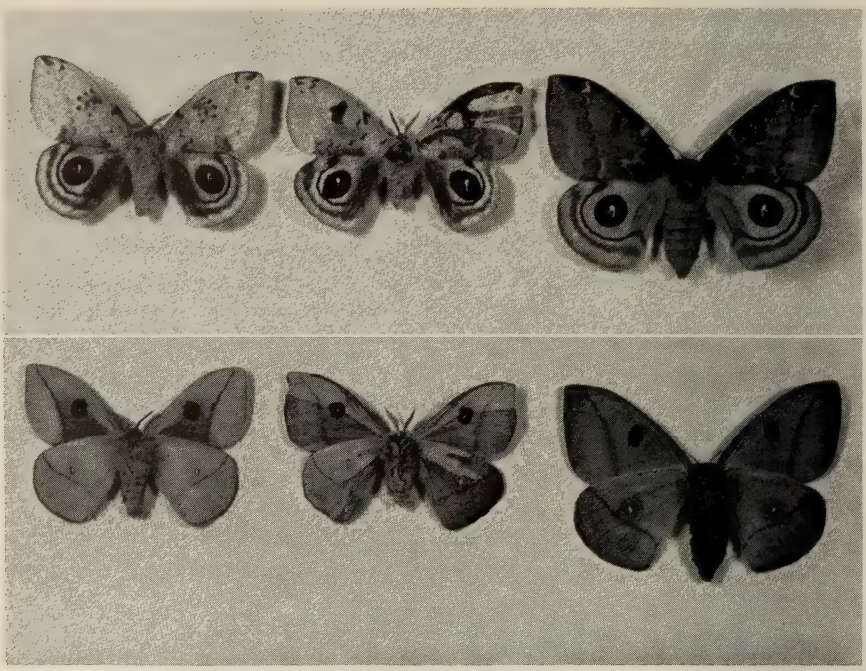


Fig. 1. *Automeris io* Fabr. Left, normal male; center, gynandromorph 19–69; right, normal female.

Gynandromorph 18–69 (Figure 2) represents one of the rarest expressions of the characters of *A. io*, the broken-eye blotch. This feature was discovered in 1965 among a group of pupae emerging that summer. It has since been bred to a population where its occurrence can be predicted. The genetics of the broken-eye blotch will be published later this year. Its size and coloration suggest it is more female than male. Comparing its size with normal specimens representing each sex shows this gynandromorph to be considerably larger than most males. This leads to an interesting speculation. Possibly the fertilized ova was female ZO which in early cleavage had a cell divide but fail to form a cell membrane dividing it into two equal cells. This may have resulted in a cell with a ZZ chromosome complement which produced only male cells.

The head of this moth is female, as evidenced by the rosy brown color and antenna. A few isolated patches of male cells are present, notably in the frons area. The thorax is predominantly female with an occasional cluster of male cells, the principal one found on the metathorax at the point of attachment of the right hind wing.

The terga of the abdomen is male with a few small patches of female



Fig. 2. *Automeris io* Fabr. Left, normal male; center, gynandromorph 18–69 with broken-eye blotch; right, normal female.

cells. The sterna is a mixture of male and female cells giving a mottled effect. The terminal, abdominal segment is male on the right side with a caudal tuft of hair covering the clasper. The left side is female. The legs are covered with a mixture of male and female colored hair-like scales.

The color patterns of the forewing uppersides are almost direct opposites. The areas on the left side which are male are female on the right side, and those that are female on the left side are male on the right. The identation along the margin of the right forewing is due to the smaller size of the male cells in that area.

The right hind wing on the upperside is male; the left hind wing is female. The unique nature of this gynandromorph is enhanced by the multiple expression of the broken-eye blotch. Several complimentary genes control the expression of the blotch, and these act quantitatively. The male right forewing reveals the blotch as a single factor expression, whereas the female left wing shows the blotch in its full expression. The right wing measures 27 mm, the left wing measures 30 mm.

The forewing underside is female. The right hind wing underside is

female from the costal margin to the medial$_2$ vein; the remainder of the wing is male. The left hind wing underside is predominantly female with a few narrow lines of male cells, the principal one being a band in the anal area along the inner margin.

As additional information on the genetics of *A. io* is unraveled we may be able to interpret more fully the behavior of cells from zygote to the mature insect. Controlled breeding is revealing many more unique patterns of this beautiful moth.

Acknowledgments

The author is indebted to Mr. Larry J. Kopp, Klingerstown, Pa., who reared the larvae; to Dr. James Cole, Bloomsburg State College, who edited the manuscript, and to Dr. Bradford Sterling, Bloomsburg State College, for the photography.

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NEUTRON IRRADIATION IN *ANTHERAEA EUCALYPTI* SCOTT (SATURNIIDAE)

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Considerable attention has been directed at the entomogenetic effects of irradiation with 14.1 MeV neutrons. Measurements of neutron induced anomalies within chromosomes furnishes a biological dosimeter. Moulton and Meyer (1970) have found in *in vivo Drosophila melanogaster* that the frequency of structural abnormalities increases with the radiation exposure level. They demonstrated that the production of dicentrics and rings corresponds closely to a curvilinear dose response curve. Supportive evidence for this has been provided by McFee *et al.* (1970) in *in vivo* swine leukocytes and Gooch *et al.* (1964) in human somatic cells.

The present study offers the results obtained from irradiation of *in vitro Antheraea eucalypti* Scott tissue cells with 14.1 MeV neutrons.

Table 1. Chromosome anomalies in *in vitro A. eucalypti* tissue cells irradiated with 14.1 MeV neutrons. Values based upon examinations of 200 cells per exposure level.

Dose rad	Chromatid Anomalies N.	Deletions %	Rings %	Dicentrics %
0	2	0	0	0
100	3	14	1	12
200	6	41	1	28
300	11	78	3	57

Entomogenetic Technique

In a radiation free area, cultures of *A. eucalypti* tissue cells were reared from ovaries of diapausing pupae. The moth tissues were incubated at 27° C in an insect tissue culture medium derived by Grace (1962). Immediately prior to irradiation, samples containing 25 ml of tissue-containing medium were placed in plastic tubes and situated 8 cm from the target of a Cockroft-Walton accelerator utilizing the D,T reaction. Doses of 100, 200, and 300 rads were supplied at a rate of 4 rad/minute.

Following this, the cultures were allowed a 48-hour recovery period. After a one-hour exposure to 8×10^{-7} M colchicine, the cells were rinsed for 15 minutes with distilled water. Cells were fixed for 15 minutes in a solution of 60 per cent acetic acid—0.1 N hydrochloric acid. Staining with 2 per cent acetic orcein preceded examination of squash preparations for chromosome structural changes.

Abnormality scoring was obtained by first scanning the coded slides at low magnification to locate suitable metaphase figures, and then analyzing them at high power. With the exception of translocations, all structural aberrations were counted. Metaphase scoring involved 200 cells at each dosage level.

Results

The neutron irradiation resulted in a pronounced breakage effect, the amount of which varied with the dosage employed. The frequency and localization of these abnormalities are summarized in Table I. As apparent from the data, an increase in the dosage level augments the production rate of anomalies, but the relationship is not linear. Instead, the findings more nearly fit a dose square model.

The mean value for one-hit aberrations per cell per rad was 5.63×10^{-3} while for dicentrics and rings it was 1.44×10^{-3}.

At the 300 rad level, evidence of mitotic ruffling was present in about two per cent of the cells scored. The author believes this to be the first identification of ruffling induced in moth tissue cells by neutrons.

Acknowledgments

The author would like to extend his deepest appreciation to Dr. Diane Edwards for her consultation and criticism of the manuscript.

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THE "ARROWHEAD BLUE," *GLAUCOPSYCHE PIASUS* BOISDUVAL (LYCAENIDAE:PLEBEJINAE)

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This started as a short note calling attention to the distribution of *Glaucopsyche piasus* Bdv. in Canada. It has developed into a study of this insect throughout its range. The Arrowhead Blue, like practically all Plebejinae of North America, was originally placed in the genus *Lycaena*, now reserved for the Coppers. Scudder (1876) created the genus *Phaedrotes* with *Lycaena catalina* Reakirt (1866) as the type species. Interestingly, Scudder considered that *catalina* was a synonym of *sagittigera* Felder (1865) yet designated it the type species. I suspect that he did this because the type of *catalina* was known to him and that of *sagittigera* was in Europe. Edwards (1884) did not accept the new genus, nor did Skinner (1898), but Dyar did (1902). Placement in *Phaedrotes* was followed in general from then (1902) until Nabokov (1945) placed the Arrowhead Blue in *Scolitantides* Hübner [1819]. Since then most authors have followed Nabokov.

The Generic Assignment

Mr. Harry Clench called to my attention the fact that *Phaedrotes* is in the tribe Glaucopsychini, and he had demonstrated that *Phaedrotes* is a subjective synonym of *Glaucopsyche!* Huebner's genus *Scolitantides* with *Papilio battus* [Denis & Schiffermuller] 1775 as type is quite different from

Phaedrotes. It is closer in appearance and structure to *Philotes* (sensu lata) Scudder. Neither Clench nor I can find any structural way to separate the Arrowhead Blue from *Glaucopsyche*. This in spite of marked pattern differences. The male genitalia, generically "good" among the Glaucopsychini, are the same in the two "genera." The venation is the same, both have similarly medium-hairy eyes and tousled long-hairy frons. Both bear androconal scales similar in size and shape with about 12 rows of reticulations each. On *piasus* these rows converge on the base of the stalk, on *lygdamus* they do not. Both utilize legumes as larval hosts. *Scolitantides* not only has different male genitalia but the larvae feed on *Sedum* and there are no androconia on the wings of the males.

Just enough work was done to fix the place of the Arrowhead Blue. It shows definitely that a careful world-wide study of the tribe Glaucopsychini is needed. Clench and I agree that the current concept of *Philotes* results in a compound genus. The type species is *sonorensis*, a *Sedum* feeder that lacks androconia (like *Scolitantides*) whereas the other species placed with it feed on *Oxytheca* and *Eriogonum* and have androconia.

Search of several museum collections demonstrates that *Glaucopsyche piasus* is not common. Personal experience with them is that they are rather local and never abundant. Perhaps because there are no really good series to study in any one collection the variation among them has been overlooked. Eight names have been used with these insects and all but one of these, *daunia* Edwards, apply to California specimens.

Study of the specimens available in the Canadian National Collection, the American Museum of Natural History, the Carnegie Museum, the Field Museum and my own collection shows that *Glaucopsyche piasus* can be divided into two groups of subspecies. For convenience I will call these the *piasus*-group and the *daunia*-group.

piasus-group: lacks a large black spot in Cu_1-Cu_2 in the submargin on the under side of the hind wing; on the under side of the forewing the spot at the end of the cell usually is small and linear, and near the middle of the cell there is a pair of small spots.

daunia-group: has a large black spot in Cu_1-Cu_2 and often in M_3-Cu_1 in the submargin of the under side of the hind wing; on the under side of the forewing the spot at the end of the cell is large and comma-shaped, the geminate spots in the middle of the cell often are fused.

The Taxa of the *piasus*-Group

The earliest name applied to the species is *piasus* Boisduval (1852). For many years this name was misapplied to a form of *Celestrina* from California. Oberthür's figure (1911) shows that the surviving male syntype represents the form of Arrowhead Blue found in the lowlands of central California. On the under side of this form there is very low con-

trast between the dull greyish ground color and the not much darker grey patterning (see Figure 2). The type is one of the sort upon which the arrowhead-shaped white marks are fused into a whitish band. Such individuals appear in all populations examined.

Another sort of Arrowhead Blue is *sagittigera* Felder (1865). It is a form with considerable contrast in the pattern on the under side of the hind wing (see Figure 5) and with a series of obscure russet spots on the margin of the upper side of the hind wing of the female. The habitat is given as "Sonora (Lorquin)." As Brown (1967) pointed out, that means, according to Boisduval, the vicinity of Los Angeles, California. *Sagittigera* has been erroneously placed for many years as a synonym of *piasus piasus*. It is the proper name for the taxon commonly called *catalina* Reakirt (see Figures 16–18). Gunder's slightly aberrant (confluent spots on under forewing) *gorgonioi* belongs to this moiety.

An unrecognized west coast fraction occurs in the northern parts of the range of the species in California and in Oregon. This is a form on the underside of which there is considerable contrast, similar to that of *sagittigera*. These butterflies differ from *sagittigera* by lacking the russet marks on the upper side of the hind wings of the female. They are almost universally confused with *piasus piasus* from which they differ in degree of contrast on the under side. I have not seen enough of this variety to name it and recommend its study to a west coast lepidopterist with sufficient material. A synopsis of the west coast names follows:

Glaucopsyche piasus piasus (Boisduval), 1852

Ann. Soc. Entomologique de France, 2nd series, 10: 229. Figured by Oberthür, 1911, Lepid. Compareé, 9: 41, pl. 237, no. 1950 (type). Type locality: "California" probably the vicinity of San Francisco. Type in U.S.N.M. (see figs. 1–4.) (*Lycaena piasus*)

viaca W. H. Edwards, 1871, Trans. Amer. Ent. Sec., 3: 209. Type locality: "Sierra Nevada, Cal." Type in A.M.N.H. (*Lycaena viaca*)

Range: From the San Bernardino Mountains, California, northward to at least Butte Falls, Jackson Co., Oregon. Except in southern California, the subspecies *piasus piasus* appears from coastal areas up to transitional forests in the mountains.

Glaucopsyche piasus sagittigera (Felder & Felder), 1865

Reise Novara, Lepidoptera II, p. 281, pl. 35, figs. 20, 21. These figures are poor but recognizable. Type locality: "Sonora" [vicinity of Los Angeles, Calif.] Type is in British Museum, Tring, Herts, England. (see figs. 5–6) (*Lycaena sagittigera*)

catalina Reakirt, 1866. Proc. Acad. Nat. Sci., Philadelphia, 16: 244. Figured by Strecker (1874) Lepid. Rhop.-Het., pl. 10, fig. 1, 2. These are fair. Type locality: Los Angeles, California. Type in Field Museum, Chicago, Ill. (see figs. 16–18, the types.) (*Lycaena catalina*)

lorquini Behr, 1867, Proc. Calif. Acad. Nat. Sci., 3: 280. Type locality: "California." Type destroyed. A letter from Behr to Strecker dated 28.viii.1875 states that *lorquini* is a synonym of *catalina* Reakirt. (*Lycaena lorquini*)

rhaea Boisduval (1869). Ann. Soc. Entomologique de Belgique 12: 51. Figured by Oberthür (1911) Lepid. Compareé 9: 43, pl. 239, nos. 2078 and 2079. Type locality: vicinity of Los Angeles, California. Type in U.S.N.M. (*Lycaena rhaea*)

gorgonioi Gunder (1925), Ent. News 36: 4, pl. 1, fig. P (colored). Type locality: San Gorgonio Mountain, San Bernardino Co., Calif. Type in A.M.N.H. (*Phaedrotes piasus catalina* ab. *gorgonioi*)

Range: Apparently restricted to the coastal regions in the vicinity of Los Angeles and now in danger of extinction.

The Taxa of the *daunia*-Group

The *daunia*-group has much wider range than does the *piasus*-group but thus far only one name has been proposed for it. It is found from northern New Mexico to southern Alberta and west into the Great Basin and northward to southern British Columbia. Within this extensive range there occurs some variation.

Material from northern New Mexico (Jemez Springs and Fort Wingate) tend to show a little russet coloring on the margins of the upper hind wing of the females. These specimens are in all other respects related to *daunia* and not *sagittigera*. The females of typical *daunia* from Colorado occasionally show a trace of russet on the upper hind wing. The broad dark vadum is reduced in the anal region to a submarginal series of dark patches. These patches of dark scales are linear or lunate and there is a noticeable lighter area marginad of them.

On the females from British Columbia, Idaho and western Washington, the vadum is broad, inwardly diffuse and totally lacking any rusty scales, nor is there any evidence of the broken crenate submarginal line, or its development, that is common to *piasus* and *daunia*. This moiety is recognized below with a subspecific name.

Glaucopsyche piasus daunia W. H. Edwards, 1871

Trans. Amer. Ent. Soc. 3: 272. Type locality: "Colorado" [Turkey Creek, Jefferson Co., Colo.] Type is in the Carnegie Museum, Pittsburgh, Pa. (see fig. 7–9). (*Lycaena daunia*)

Range: From northern New Mexico through the Rocky Mountains to Alberta. The Alberta specimens in the Canadian National Collection, Ottawa, Ontario, are these: Calgary, head of Pine Creek, 31.v.1915, F. H. Wolley-Dod, 1 ♂; Cypress Hills, nr. Elkwater, 4500 ft., 13.vii.1951, D. F. Hardwick, 1 ♂; Lethbridge, 30.vi.1923, J. McDunnough, 1 ♂ (illustrated); Waterton Lakes, 24.vi.1922, C. H. Young, 1 ♂, and 8.vi.1923, J. McDunnough, 1 ♂.

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Glaucopsyche piasus toxeuma Brown, **new subspecies**

Male. Upper side violet blue as on *sagittigera,* not specular blue as on *daunia.* Vadum relatively narrow, inwardly diffuse. Fringes checkered white and black with the black at the ends of the veins.

Underside: Darker and more contrasty than typical *piasus,* about as on *daunia.* Background about the same shade of grey as on *daunia,* not as brownish as on *sagittigera.* Forewing submarginal angular interneural marks poorly defined, especially in apical area (similar to *sagittigera*), not as sharply defined as on *daunia.* Post discal row, black spots circled with white, essentially the same on all subspecies. The two cell spots on *toxeuma* are equally strongly developed and on the whole larger than on *piasus* and *sagittigera* and more like on *daunia.*

Distal notch of each sagittate white mark on hind wing outlined in black, not as sharply as on *daunia* but more like on *sagittigera.* These marks larger on *toxeuma* than on either *daunia* or *sagittigera.* In submargin between Cu_1 and Cu_2 a black spot capped with a diffuse crescent of rusty scales and then black caret at base of white sagittate mark. A similar, much less noticeable mark just anterior to anal vein. Occasionally such a mark found in M_3-Cu_1. These marks absent from *piasus* and *sagittigera* and usually more highly developed in *daunia* than on *toxeuma.*

Female. Similar coloring to male with broader vadum. Vadum on forewing often reaching end of cell and diffuse inwardly. On hind wing no evidence of the submarginal sharply defined broken crenate line found on *daunia* nor diffuse rusty patches seen on *sagittigera.*

Under side: As on the males with post discal series of spots often incomplete. In these cases the minute spots between R_s-M_1, M_3-Cu_1 and Cu_1-Cu_2 disappear.

In addition *toxeuma* tending to be somewhat larger than specimens of the other subspecies.

Holotype. No. 11,470, a male from Garnett Valley, Summerland, B. C., 22.v.1933, A. N. Gartrell in the Canadian National Collection, Ottawa, Ontario. Radius of left forewing, 16.7 mm. Allotype: a female from the same series as the holotype but collected on 10.v.1933. Radius of left forewing, 17.0 mm. Paratypes: 9 males and 4 females collected 10–28.v.1933 by either A. N. Gartrell or J. McDunnough. All in the Canadian National Collection.

The name is a transliteration of the Greek word for "that which is shot," in other words, an arrow. The holotype and allotype are shown in Figures 13–15.

Range: South central British Columbia southward in eastern Washington and Idaho (at least to Pocatello).

Although I have restricted the type series to specimens from the type locality, the Canadian National Collection contains the following material assignable to *G. piasus toxeuma*:

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Figs. 1–18. *Glaucopsyche piasus* Bdv. 1–4, *G. piasus piasus* Bdv., San Francisco, Calif., coll. F.M.B.; 5–6, *G. piasus sagittigera* Felder, Los Angeles, Calif., C.N.C.; 7–9, *G. piasus daunia* Edw., Boulder, Colo., C.N.C.; 10, *G. piasus toxeuma* Brown, Pocatello, Ida., coll. F.M.B.; 11–12, *G. piasus daunia* Edw., Lethbridge, Alta., C.N.C.; 13–14, *G. piasus toxeuma* Brown, Garnett Valley, B. C., holotype, C.N.C.; 15, *G. piasus toxeuma* Brown, Garnett Valley, B. C., allotype, C.N.C.; 16–17, *G. piasus catalina* Reakirt, lectotype, Field Mus.; 18, *G. piasus catalina* Reakirt, paratype female, Field Mus.

BRITISH COLUMBIA: Keremeos, Shingle Creek Rd., 9.vi.1933, A. N. Gartrell, 1 ♂, and 18.vi.1933, C. B. Barrett, 1 ♂; Okanagan Falls, 15–23.v.1953, J. R. McGillis, 3 ♂♂; Oliver, 14–15.vi.1953, D. F. Hardwick & J. E. H. Martin, 3 ♂♂, 1 ♀; Osoyoos, 19.v.1895, 1 ♂, 23.v.1895, 1 ♂, 19–24.vi.1938, J. K. Jacob, 14 ♂♂, 7 ♀♀, and 15–22.vii.1953, J. R. McGillis, 7 ♂♂, 2 ♀♀; Osoyoos, Anarchist Mt., 7.v.1936, A. N. Gartrell, 1 ♂; Penticton, 23.v.1953, J. R. McGillis, 1 ♂; Summerland, Garnett Valley, 10–28.v.1933, J. McDunnough & A. N. Gartrell, 10 ♂♂, 5 ♀♀, type series of *toxeuma;* Vasseau, 14.v.1920, W. B. Anderson, 1 ♂; Vernon, 20.v.1906, Bush-Wilson, 1 ♂, 12.v.1908, 1 ♂, 22.v.1919, W. B. Anderson, 1 ♀, and 16.v.1953, D. F. Hardwick & J. E. H. Martin, 4 ♂♂, 5 ♀♀.

In addition to the above there is a short series in my collection from Robson, B. C., collected by N. R. Foxlee on 23–26 May in 1936 and 1937. Except for these it might be assumed that the subspecies is confined to the Okanagan Valley in British Columbia. The distributional data for such an assumption probably is in artifact of collecting. Very definitely there is a lack of material from both east and west of the Okanagan Valley in the Canadian National Collection. When that is remedied we will have a better idea of the range of *piasus* in Canada.

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A RECORD OF *EUPHYDRYAS ANICIA* (NYMPHALIDAE) IN OKLAHOMA

In June 1959, I took a male of *Euphydryas anicia* Doubleday at Lawton, Comanche Co., Oklahoma near Fort Sill, a major artillery training base for the Army. It seems possible that a pupa or a number of pupae were brought to Fort Sill in some plants a soldier brought with him or in a shipment of goods to the base. This seems the only plausible explanation of *anicia's* presence in Oklahoma, hundreds of miles from it's nearest recorded range.

I have collected in Lawton for eight seasons since 1959, mostly in June, and have never seen another specimen. This is the first record of the species from east of the hundredth meridian in Oklahoma that I have knowledge of.

The author would like to thank Mr. F. M. Brown, Fountain Valley School, Colorado Springs, Colorado, for reading the manuscript and offering his suggestions.

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REARING TECHNIQUES FOR SPECIES OF *SPEYERIA* (NYMPHALIDAE)

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Widespread interest in North American *Speyeria* has resulted in accumulation of considerable taxonomic and ecological information, yet problems in understanding species limits persist.

Rearing studies would be helpful in clarifying some of these problems, but until now no successful method of breaking larval diapause or of overwintering was known. This paper outlines rearing procedures developed by the authors during five years of combined research. We have used the method to rear more than 4,000 specimens, including all the Nearctic species. Although large scale rearing is described, its fundamentals can be reduced to the scale desired.

A search of the literature provides little information on rearing *Speyeria*. William Henry Edwards (1887) wrote of successfully overwintering larvae in an ice house. Grey, Moeck, and Evans (1963) reported a method of breaking diapause by periodic mechanical stimulation over an extended period. Little was learned concerning the origin of an idea which was developed into the overwintering procedure described in this paper as the "block method" of larval storage. The idea came to us through D. V. McCorkle of Monmouth, Oregon, who along with others explored it as a means of overwintering.

The Speyerian Life Cycle

A generalized life cycle for *Speyeria* may be useful in understanding the complexities of rearing. The one presented is based partly on our observations and partly on descriptions in literature.

Species of *Speyeria* are univoltine; adult emergence occurs between May and September, depending on the population. The males appear approximately a week before the females, which results from a disproportionate larval growth rate. Females often mate immediately, sometimes on or before their maiden flight. Egg laying begins within days or weeks depending on differing ovarian maturation rates between species. Food plants appear to be restricted to the genus *Viola* (Violaceae) with one doubtful exception offered by Durden (1965). Oviposition sometimes

occurs on the food plant, but commonly eggs are placed on other substrates near the host. More than 600 eggs may be deposited by a single female. The time from oviposition to eclosion under natural conditions ranges from 12 to 24 days depending on the species. We have noted a relatively uniform rate of development under laboratory conditions. Eggs held at temperatures between 24° to 32° C darken within 48 hours if viable, and hatch in approximately 9 days. After emergence, larvae immediately seek shelter in ground litter and hibernate. All *Speyeria* larvae overwinter in a state of diapause, remaining inactive for at least 8 months; mortality appears to be very high during this period.

Following appropriate stimuli in the spring, feeding starts, and the larvae grow to maturity in 6 to 10 weeks. The time from pupation to emergence varies from 7 to 22 days in the laboratory depending on the species and the temperature to which the pupae are exposed. The average length of the pupal period in nature is reported to be approximately 14 days, (Weed, 1927; Macy and Shepherd, 1941).

Field Storage and Handling of Live Females

Proper handling permits storage of live females for extended periods and successful shipping within North America in a condition to produce an ample supply of eggs. Field collected females should be placed with their wings closed in glassine envelopes without being stunned or anaesthetized. A portable ice chest should be taken where hot, arid conditions will be encountered, or on trips of more than one day. Enveloped females should be kept in tightly sealed glass jars stored in ice. Lengthy storage in ice will keep the insects immobile, and is not harmful as long as desiccation does not occur. The loss of body moisture is a great shipping and storage hazard and may be prevented by the addition of moistened paper towel or the equivalent to the jar. However, adding or accumulating too much moisture can drown the insects. Also, water can be accidentally drawn inside from the melting ice especially when a vacuum is created inside jars as they are cooled or by transporting them from a high to a lower altitude.

If storage will be longer than 3 days, females should be fed. One initial feeding will allow them to be carried for several weeks as long as jars are occasionally opened to replenish the oxygen supply and the cold is maintained. Similar success with storage has been obtained in the laboratory by holding the jars under refrigeration.

Shipment of Living Females

A double box method has proven to be safe and effective for shipping. The insects (in glassine envelopes) are packed in small loose groups in

dampened absorbent packing material in a durable, crushproof container. The container is sealed with waterproof packaging tape to help retain moisture, and is then surrounded with packing material in a slightly larger container. After packaging, shipments are held under refrigeration until air mailed. At destination, the females should be fed immediately or the package again refrigerated.

Adult Feeding Procedure

Females bagged for egg laying should be fed twice daily. The food solution and feeding procedure is similar to that given by McFarland (1964). The solution consists of 3 heaping teaspoons of granulated sugar to 8 ounces of distilled water.

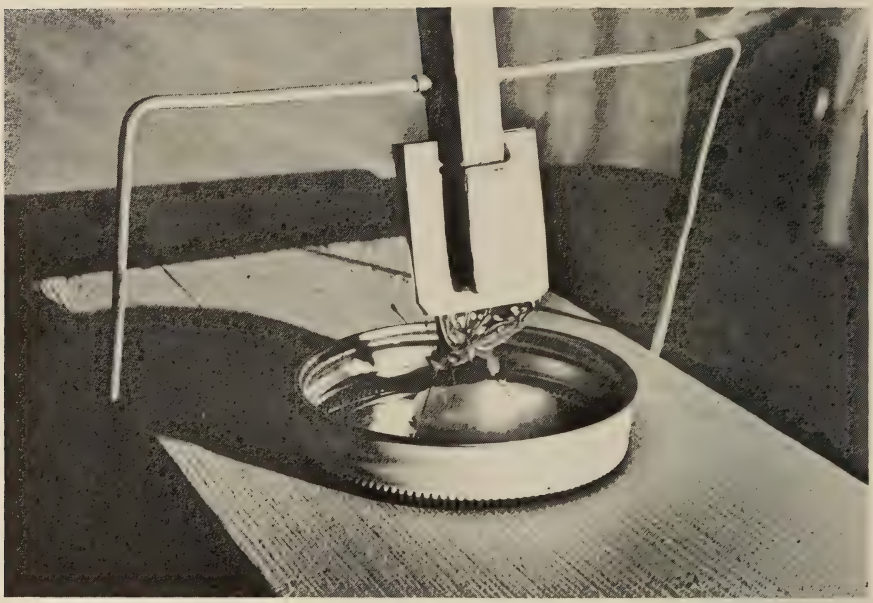
The butterfly, with its wings closed, is placed on absorbent cotton saturated with the solution. Organs of taste in the tarsi of the posterior pair of legs normally trigger a feeding response (Ford, 1945; Macy and Shepard, 1941; Oldroyd, 1959); however, if the response fails a pin can be inserted through the proboscis coil extending it into contact with the solution. Feeding lasts approximately 2 to 3 minutes with old, worn, or egg laying females. Unproductive individuals may not feed as long.

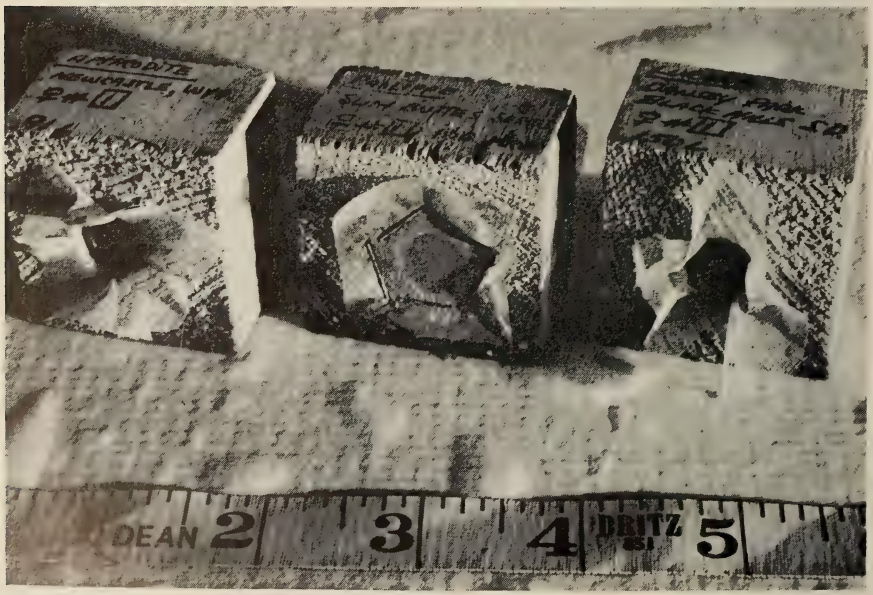
Adjustable holding devices like the one shown in Figure 1 are convenient when numerous females must be fed. In the one shown, a clothespin provided with cardboard grips can be adjusted to the height and angle necessary for holding any size specimen for feeding. Traces of food solution should be rinsed away from the insects tarsi and proboscis after each feeding, otherwise chrystallizing sugar may damage these organs.

Oviposition in Captivity

Following the method used by Grey, Moeck, and Evans (1963), egg laying can be promoted by enclosing the female in a brown paper bag exposed to sunlight. In the laboratory an incandescent light source is used. Size number 8 paper bags containing violet leaves are placed 12″ to 18″ from a 100 watt light. The best egg production is obtained when bags are exposed to a humid environment. Where dryness cannot be avoided, the paper bags can be enclosed in plastic bags and about 1 tablespoon of water added between them as needed to avoid desiccation of the females.

Generally most field collected females are gravid, but fresh specimens of some species must be bagged for many days before oviposition begins. Females are usually so worn by the end of the egg laying period that photographic records are necessary to compare progeny and parent.





Figs. 1, 2. 1, An adjustable feeding device for holding butterfly immobile during feeding; 2, dampened wooden blocks containing diapausing Speyerian larvae and showing two methods of attaching the nylon chiffon.

Method of Larval Storage

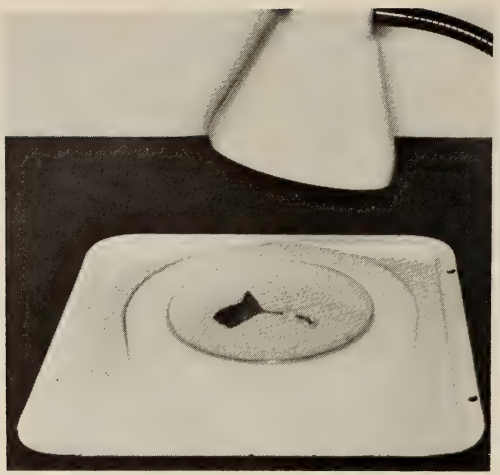
Newly hatched larvae are immediately removed from the bag and are housed in small wooden blocks. These blocks, which are approximately 1½″ cubes, are preferably made of basswood or other soft lumber. A hole ½″ diameter is drilled with the grain of the wood through the center of each block to form the storage chamber.

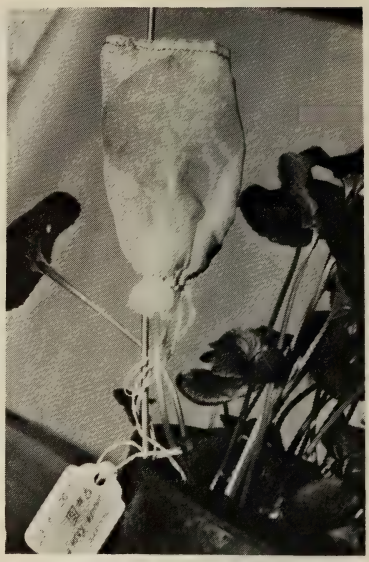
Up to 100 larvae may be housed in an individual storage block. The storage compartments are closed either by stapling nylon chiffon over the holes (chiffon is used because it allows ventilation while preventing larval escape) or by inserting it inside each end by use of plastic compression rings (Fig. 2). Parakeet banding rings adapt well for closing blocks because of their ability to expand and contract. Chiffon attachment by stapling when the blocks are dry will remain tight throughout periods of expansion and shrinkage resulting from periodic block soaking. Soakings are mandatory throughout larval storage, as desiccation is fatal to the larvae. The interval between soakings depends on dryness of storage conditions, but usually is not longer than a week. Blocks are soaked until partially wet by absorption in distilled water not deep enough to enter the storage chamber.

Blocks must be stored at all times under refrigeration at a temperature just above 0° C, as freezing of the blocks will cause high larval mortality. The blocks should be arranged in a tray or the refrigerator's vegetable pan so that adequate ventilation can pass through the storage chambers. Mold growth inside damp blocks is a serious problem as mold growing around larvae will usually cause death. Autoclaving of the blocks before use, and periodic inspections during storage is necessary. When mold is detected reblocking must be undertaken.

The overwintering larval condition referred to in this paper and in literature as "diapause," may ultimately prove to be quiescence. Throughout diapause, *Speyeria* larvae demonstrate an ability to repeatedly awaken from or return to dormancy in response to the application or removal of stimuli such as light, heat, and mechanical agitation. The ability to seek shelter from adverse environmental conditions may have an important influence in larval survival in nature.

Apparently, a correlation exists between larval metabolism and the agent controlling diapause. Apparently diapause cannot be permanently terminated until a given amount of stored energy has been expended. The rate of expenditure seems to regulate termination. Furthermore, the rate appears to fluctuate with temperature; thus, diapause ends more rapidly for larvae stored at room temperature (22°–26° C) than for those stored in the cold (1°–5° C). Carefully controlling the metabolic rate by refrigeration to approximate natural habitat temperatures is therefore necessary





Figs. 3, 4. 3, Humidity chamber apparatus for breaking larval diapause (feeding is promoted by the application of controlled heat, light, and humidity); 4, a bag type leaf sleeve of nylon chiffon is placed on violet leaf.

to extend diapause to its normal duration. Conversely, the rapid expenditure of energy through intense and continued artificial stimulation can rapidly terminate diapause in all *Speyerian* species.

Breaking Speyerian Diapause

Figure 3 shows an arrangement developed for breaking Speyerian diapause. This method employs light, heat, and humidity for stimulus and protection, and is designed for use at indoor temperatures (22°–26° C). The equipment consists of a white, enamel plated tray, or other reflective surface on which is placed a small, clear plastic box or glass petri dish. Paper towel or filter paper fitted in the bottom of the container is saturated but not flooded with distilled water. A young tender violet leaf with its stem held by foam rubber in a 8×25 mm water filled specimen vial is placed in the container. Using a camel hair brush, up to 30 larvae can be placed in the container. The larvae will partially awaken and contract into a C-shaped position in response to the handling. An adjustable gooseneck, hooded lamp using a 60 watt incandescent bulb is positioned approximately 8 inches from the container shining down on the larvae. After larvae uncoil and begin to crawl in response to the heat and light stimuli, they should be transferred to the leaf. A top is placed on the container to form a miniature escape proof humidity chamber in which the larvae

will not be harmed as long as the towel moisture is maintained. Reflective insulation material (such as expanded polystyrene) is cut to enclose the container exposing only the lid. This will substantially reduce condensation inside the chamber, in which wandering larvae can be trapped and drowned.

The time required for the first feeding response to occur is highly variable, and as previously stated, appears to depend on how much stored energy remains to be expended. During this interval the larvae may crawl extensively with intermittent periods of attempted sleep, often under the leaf or along the sides of the humidity chamber. The first indication of feeding is the appearance of small nicks along the margin of the leaf. Feeding occasionally occurs within 30 minutes, but normally takes from 1 to 3 days or longer. Feeding larvae usually display a gregarious tendency through the first 2 to 3 instars.

Host Plants

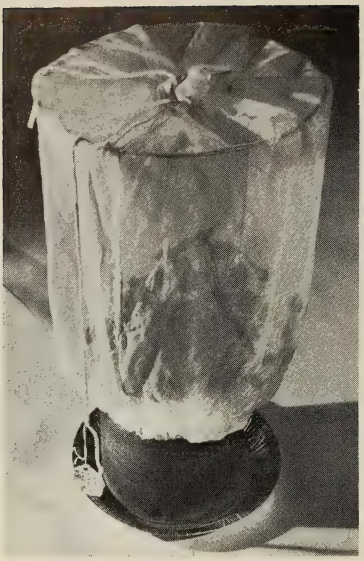
Many North American violets of the genus *Viola* serve as satisfactory hosts. Although there appear to be host preferences throughout the genus, indiscriminate feeding on any available *Viola* apparently occurs (Macy and Shepard, 1941, for S. *cybele*). The only unsuitable violets encountered are evergreen ornamentals of European origin. Although larvae of most species will accept an unsuitable host, symptoms possibly indicative of a nutritional deficiency or a toxic reaction, will develop in varying degrees depending on the species involved. Some species are quickly killed, while in others dwarfed adults have been obtained after an abnormally long development period.

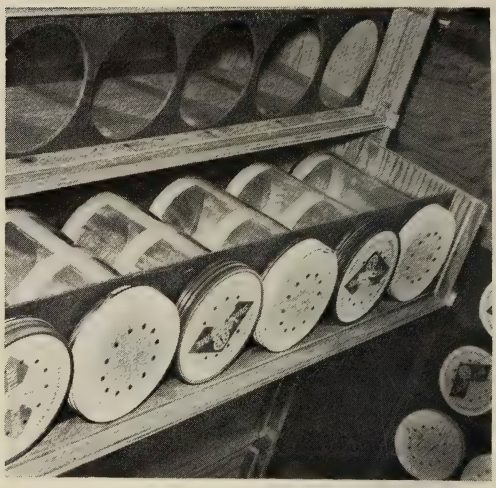
Viola papilionacea Pursh, and the partial albino form *V. priceana* Pollard have proven to be very successful hosts for all North American *Speyeria*. These large leafed deciduous plants are excellent seed and foliage producers which withstand repeated defoliation, and can be grown continuously in greenhouses with only a short winter dormancy.

Rearing Procedures

Larval losses are minimized by allowing completion of the approximate 2-day first instar period in the humidity chamber. They are then transferred to host plants where second and third instar development continues on young tender violet leaves in the confinement of a leaf sleeve. Figure 4 shows a nylon chiffon leaf sleeve securely closed by a drawstring which crimps cotton around the leaf petiole. Violets for sleeving are container grown for handling convenience. Leaf-sleeving becomes impractical by late third instar due to increased larval size and food consumption.

As shown in figure 5 the remaining larval development takes place in





Figs. 5, 6. 5, Nylon chiffon can-sleeve installed on container-grown *Viola;* 6, cabinet providing partial temperature and humidity control for storing pupation and emergence jars in dark.

a nylon chiffon can-sleeve. The wire legs of the sleeve support ring when pushed into the soil hold the sleeve in position. An elastic band in the bottom of the sleeve grips the can snugly while access is gained through the top by means of a draw string.

Violet plants can become infested with several common pest or disease organisms in addition to harboring hard to detect spiders which can kill early instar larvae. When pest control becomes necessary, washing the foliage or hand removal is recommended. *Speyeria* larvae exhibit a pronounced sensitivity to many commonly used home and garden pesticides, and any treatment should also include precautionary foliage feeding tests before plant reuse. Residual or systemic insecticides and those releasing fumes including household pest strips should be strickly avoided. Soil in the container may still be contaminated after the plant has proven safe. A layer of sawdust will prevent soil contact and will collect and help desiccate larval droppings for easy disposal.

The feasibility of conducting large scale rearing studies was greatly enhanced by learning that the normal more than 3 month larval-pupal development period could be significantly reduced. As with most insect development, heat is a major factor in shortening the maturation period. In nature, feeding is slowed or interrupted by the intensity of direct sunshine or nighttime cold. Where sleeved cans of larvae are placed under

continuous incandescent light at a temperature from 26° to 32° C with moderate humidity, the subdued light within the sleeve seems optimum for a rapid development of the normally nocturnal larvae.

An extreme example of accelerated development was achieved where normal males of *Speyeria callippe marcaria* were obtained in 20 days from first feeding to adult emergence, but the higher temperature levels needed are highly favorable for disease development.

Pupal Storage and Adult Emergence

Chrysalids should be stored in separate emergence jars during their development period. If full-grown larvae are transferred to jars for final development, the usual indications of oncoming pupation are discontinued feeding, rapid and continuous wandering, and finally a reddish discoloration to the larval droppings. If pupation occurs in the can-sleeve, masking tape can be used to easily detach and resuspend chrysalids in the jars without removing them from their silken attachment.

Newly emerged adults normally undergo nervous body movements which are apparently a functional part of the wing expansion process. Three-fourths of the inside circumference of the approximately 2 quart capacity wide mouth jars, are lined with moisture resistant Dacron curtain material held in place with "freezer type" masking tape. The lining provides an adequate foothold surface which reduces wing damage that results when adults accidently fall during emergence and cannot retain a hanging position. A gap is left in the lining large enough to lay a restaurant dispenser type paper napkin when the jar is on its side. The napkin, which is kept slightly damp to provide humidity for normal pupal development, also helps collect larval droppings before pupation and absorbs the reddish waste material released by the emerging adult.

Addition of water and finally the killing agent can be easily applied to the napkin with a plastic squeeze bottle through a hole drilled in the jar lid. Figure 6 shows a jar cabinet designed for large scale rearing. The storage drawers have removable fronts for easy access to the jars, while the cabinet provides temperature control and a darkened interior for emergence.

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A NOTE ON *LETHE ANTHEDON BOREALIS* (SATYRIDAE)

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In recent years the genus *Lethe* Hubner has inspired a good deal of new interest by North American Lepidopterists; Irwin (1970) has treated *Lethe creola* (Skinner); dosPassos (1969), Shapiro and Carde (1970) and Carde, Shapiro and Clench (1970) have treated the *Lethe eurydice* (Johansson)—*Lethe appalachia* Chermock complex while Heitzman and dosPassos (in preparation) are treating the *Lethe anthedon* Clark—*Lethe portlandia* (Fabricius) complex. As a result of these studies, the number of recognized species of *Lethe* in North America is increased from three (as given by dosPassos 1964) to five. Included are two sets of sibling species, *eurydice-appalachia* and *creola-portlandia-anthedon*, which show very little morphological divergence but exhibit strong physiological distinctions which warrant their current designations as separate species. In view of this, the physiological differences between *Lethe anthedon borealis* Clark, per my observations in Minnesota, Wisconsin, Ontario and Manitoba, and nominate *L. a. anthedon* seem quite pertinent. They should shed some light on the proper relationship of the two subspecific popu-

lations and indicate the value in retaining *borealis* as a subjectively valid name.

Lethe anthedon borealis was described from Hymers, Ontario by Clark (1936) as *Lethe portlandia borealis* in the same paper in which *Lethe portlandia anthedon* was described. *Borealis* has received but little interest, usually having been regarded as a "very weak" subspecies of *portlandia* (= *anthedon sensu stricto*) or as a subjective synonym for *anthedon*. The morphological differences, cited by Clark to separate the two subspecies, are indeed slight; they are as follows:

> Dark border on hind wings above narrow and tapering anteriorly; on the hind wings below the dark band, between the light line bordering the fourth and fifth spots and the submarginal light line, is little, if at all, broader than the distance between the submarginal light line and the margin of the wing *anthedon* Clark
> Dark border on hind wings above broader and more uniform, not narrowing appreciably anteriorly; on the hind wings below the dark band between the light line bordering the fourth and fifth and the submarginal light line is broader, usually much broader, than the distance between the submarginal light line and the edge of the wing; ground color below browner and usually more uniform *borealis* Clark

These distinctions are minor and difficult to use in keying out specimens and it is almost necessary to have both populations available for comparison; however, *borealis* is not often represented in collections. The character that I have found most useful in separating populations is the ground color of the hind wings below; in *borealis* it is a dull and uniform brown while in *anthedon* the background seems to be composed of several shades of brown and is much brighter. This distinction is especially evident in looking at the butterflies in series, which avoids comparing individual differences. I have also found that the morphological distinctions between the two populations occur on a sharp line between the Transition and Canadian Life Zones. Munroe (1969) stated that a number of butterflies exhibit sharply distinct subspecies on the two sides of a boundary between two major ecological formations. As examples he cited, among others, *Papilio glaucus canadensis* Rothschild & Jordan and *Limenitis arthemis arthemis* (Drury) for the Canadian Zone versus *Papilio glaucus glaucus* Linnaeus and *Limenitis arthemis astyanax* (Fabricius) for the Transition Zone.

After carefully examining the specimens of *Lethe anthedon* in my own collection and in the University of Minnesota collection, I placed them, subjectively, into subspecies *borealis* or *anthedon* and plotted their distribution (Fig. 1). The correlation between subspecies and life zones is

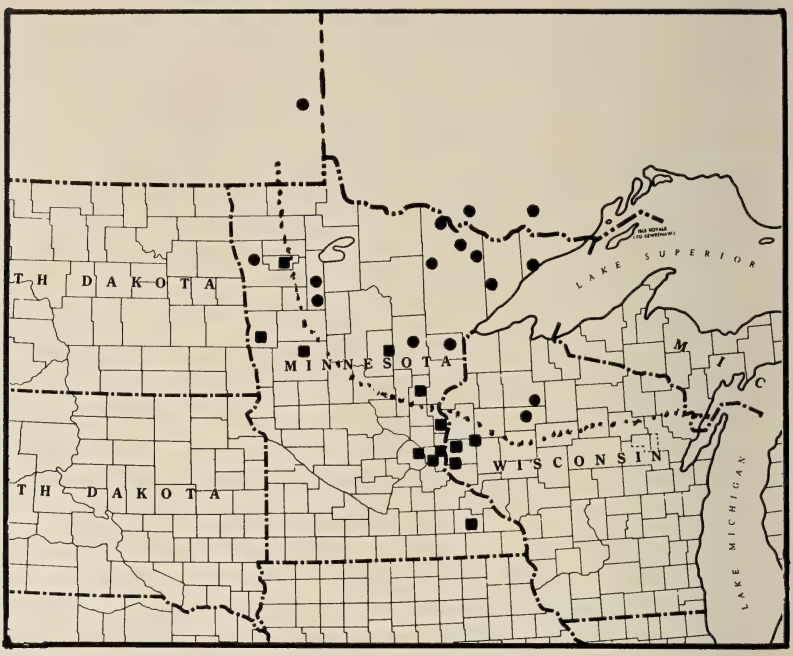


Fig. 1. Distribution of examined specimens of *Lethe anthedon* in Minnesota and neighboring areas. Circles: *Letha a. borealis* (Clark). Squares: *Lethe a. anthedon* (Clark). Dotted Line: approximate boundary between Canadian (Boreal Region) and Transition (Austral Region) life zones.

very good; as indicated by the dotted line on the map which traces the approximate boundary between the Canadian and Transition Zones (per Roberts, 1936). Nearly every specimen examined could be placed reliably into one subspecies or the other. Some degree of intergradation was noted in the character of the dark border on the dorsal hind wing, and to a lesser extent in the other characters, but in no case was more than one character involved in intergradation.

The differences in habitat and habits are much more conspicuous. My observations on *Lethe anthedon anthedon* have been principally in southern Minnesota, central Wisconsin, Missouri and Arkansas, but are in complete accord with Shapiro and Carde (1970) for New York and New Jersey, Klots (1951) and Edwards (1897). Nominate *anthedon* is a shade loving butterfly of deciduous forests. It's foodplants are grasses, *Brachyelytrum erectum* Schreb. (Shapiro & Carde, 1970), *Uniola latifolia* Michx. (Heitzman, 1970) and possibly others. The butterflies frequent small glades in the forest and exhibit strong preferences for flight in the late afternoon, often flying until dusk. They are infrequently taken at lights which may

indicate that they, like *Lethe creola,* are subject to occasional nocturnal flight. The males are very territorial in habit and each male will occupy a favorite perch at some distance from the perches of his nearest neighbor. The distance between perches is inversely proportional to the population density in the particular locality and, if the population density is extremely high, they may be very close together and, in some cases, even on the same tree. The perches are almost invariably on a tree trunk, two to four feet off of the ground, which allows a view of a small glade or opening in the forest. Territoriality very similar to this has been recorded for a number of other satyrid butterflies, e.g. *Oeneis macounii* (Edwards) and *Oeneis jutta* (Hubner) (Masters & Sorensen, 1969), and apparently serves the mating requirements of the butterflies.

Based on my observations, primarily in Rusk County, Wisconsin, Aitkin and Saint Louis Counties, Minnesota and Riding Mountain, Manitoba, *Lethe anthedon borealis* has distinctly different habits and habitats. It does not occupy the fully wooded environment but prefers a very "open" wooded environment with lush undergrowth, the mosaic habitat of Shapiro and Carde (1970). In some cases I have found colonies in localities where bogs or marshes are gradually giving way to forest and the plant associations are quite mixed. In other cases I have found them in young seral forests, composed of birch, aspen and hazelnut growing sparsely with heavy undergrowths. The foodplant of *Lethe anthedon borealis* is not known. One of the recorded foodplants for nominate *anthedon, Brachyelytrum erectum,* occurs at least in part of it's geographic range (Lakela, 1965), however *Uniola latifolia* does not. The actual foodplant may prove to be *B. erectum* or another grass, but I would not be suprised to learn that it was a sedge instead since several species of sedge are common in the *borealis* habitats.

Like the nominate subspecies, *L. a. borealis* exhibits a marked preference for late afternoon flight and may be taken until sunset on warm days. At Riding Mountain, Manitoba, it is always the last butterfly on the wing each day and can be taken on overcast days when few or no other butterflies are flying.

The greatest behavior difference between *borealis* and nominate *anthedon* is that *borealis* exhibits none of the territorial characteristics that are so pronounced with *anthedon* and is, in fact, quite gregarious in habit. Large numbers of *borealis* are frequently seen congregating together about a single bush or group of bushes, usually at the edge of a road or a forest opening. They seem to be quite "amiable" together and the aerial encounters of males, that are so common with nominate *anthedon* and territorial species never occur. Unlike nominate *anthedon,* they very seldom perch on tree trunks but prefer perches on low shrubbery, usually less than

a foot off the ground. When alarmed, their favorite tactic is to dodge deeper into the bush they are on, which makes pursuit by a larger predator very difficult. Dozens of *borealis* are sometimes encountered clumped together while feeding at carrion or excrement or at a shaded, damp spot in a road. Assemblies of nominate *anthedon* at damp spots or while feeding are not uncommon, but the tendencies are not as pronounced and the numbers involved are not as large.

The range of *Lethe anthedon borealis,* as far as known, includes: southern Manitoba, west to Riding Mountain; northeastern Minnesota, south to Aitkin and Carleton Counties; northwest Wisconsin, southeast at least to Rusk County; and the part of Ontario that is immediately north of Minnesota and Lake Superior. It probably occurs further east in Wisconsin and, quite likely, in the northern peninsula of Michigan. No attempt has been made to determine the eastern limit in Ontario.

One of the major criticisms leveled at the trinominal and it's usage in taxonomy is that the subspecies, as currently defined and used, fails to distinguish between weakly and strongly differentiated geographic subspecies and treats them all alike. Descriptions and identifications of populations are essentially based on visible morphological distinctions and consequently taxonomy has been strongly oriented in this direction and populations which show strong morphological divergence have attracted the most attention. However, we have in *Lethe anthedon borealis,* a very good example of very marked physiological (behavioral) differences along with very weakly developed morphological differences. Differences between species, subspecies, or any taxonomic category, may be physiological, morphological, or both, and they may be phenotypic or genotypic in each case. Fortunately physiological differences, which are far more important in the long run, are usually accompanied by at least minor morphological changes which allows the taxonomist to distinguish and name the populations exhibiting them. On the other hand, so far as we know, morphological differences are usually accompanied by at least minor physiological differences; if they weren't, there would be little point in pinning a name on them. Unfortunately, however, there is not always a correlation. Remington (1968), for instance, stated that he had under study three species of butterflies in Connecticut and four in Colorado, each of which he felt was a pair of widely sympatric and fully speciated entities. He had, however, delayed formal naming of these species because he had not yet found [morphological] recognition characters useful for determining museum specimens.

The North American *Lethe* constitute a good example of the problems in relying exclusively on morphological characters for species distinctions. Ehrlich (1961) cited *Lethe* as one of only fourteen North American genera

of butterflies that represented no problem to the taxonomist because speciation is quite distinct. Since that time field work and behavioral studies have forced us to increase the number of recognized species from three to five and we have become aware of classification problems in the populations of *borealis* and *fumosus* Leussler, both of which are still treated as infraspecific, but with reservations.

The physiological distinctions that I have observed between *Lethe anthedon anthedon* and *Lethe anthedon borealis* are of the same magnitude as Shapiro and Carde (1970) found between *Lethe eurydice* and *Lethe appalachia*, and which they used as justification for separating them into two distinct species. *Lethe eurydice* and *Lethe appalachia* are sympatric over a wide range, while, as far as is known, *Lethe a. anthedon* and *Lethe a. borealis* are allopatric or nearly so. Thus the retention of them as subspecific entities is justifiable.

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DESCRIPTIONS OF LARVAE OF TWO EASTERN SPECIES OF *LYGRIS* (GEOMETRIDAE)

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The larvae of seven Canadian species of *Lygris* were described by the writer (1958) in *Larvae of the Nearctic Larentiinae*. Since then two more species, *L. explanata* (Walker) and *L. molliculata* (Walker), have been reared. The descriptions of these appear here. One other, *L. serrataria* Barnes and McDunnough, remains to be studied. A key to known larvae of *Lygris* is presented.

Lygris explanata Walker

Cidaria explanata Walker (1862, pp. 1422–1423).

Type locality unknown.

Range: Southern Labrador, Newfoundland, and Nova Scotia, west to Lake of the Woods and south, according to Forbes (1948), to Massachusetts and New York.

Host: *Vaccinium*.

Life History: Hibernates as egg; larva free-living (four instars), late May to July 18; pupal period 14 to 18 days; adult late July to August.

Description: I. Head brown; body light brown or yellow, with brown middorsal stripe; yellow line in upper, and brown line in lower, subdorsal region; wide brown midventral line. H.W., 0.38 mm; B.L., 3.6 mm; B.W., 0.4 mm. II. Head light brown with suggestion of brown streaks over lobes. Body light brown with dark brown middorsal stripe; fine brown line in subdorsal region; brown adventral line; dark brown midventral line. H.W., 0.54–0.58 mm; B.L., 8–13 mm; B.W., 0.6–0.7 mm. III. Head light yellow with fine rust-coloured spots arranged in herring-bone pattern on sides of head, along epicranial stem and on sides of clypeus. Body light brown; middorsal line dark grey, in an irregular grey stripe; rust line in subdorsal region; adventral line chocolate; midventral line dark brown. H.W., 0.98–1.00 mm; B.L., 14 mm; B.W., 1.0–1.1 mm. IV. Head light brown with brown specks arranged in herring-bone pattern along epicranial stem and over parietal lobes. Body light brown; markings dark grey to reddish brown (Fig. 1). Seta L1 on low tubercle, circled in dark grey. Thoracic plate concolorous; anal plate concolorous, with dark median furrow. Thoracic legs light brown; prolegs reddish brown. H.W., 1.67 mm; B.L., 27–35 mm; B.W., 2.0–2.4 mm.

Remarks: Description based on larvae reared from eggs and collected from *Vaccinium* in vicinity of Laniel, Quebec.

Lygris molliculata Walker

Cidaria molliculata Walker (1862, p. 1390).

Type Locality: St. Martin's Falls, Albany River, Ontario.

Range: Ontario, north and west to the type locality; western Quebec, east to Ste. Foy; and in the United States, according to Forbes (1948): Minnesota, Pennsylvania and New York.

Host: *Physocarpus opulifolius* (L.) Maxim.





Figs. 1 and 2. *Lygris* spp., mature larva, setal and colour patterns on third abdominal segment. 1. *L. explanata* (Walker); 2. *L. molliculata* (Walker).

Life History: Larva free-living (five instars), in June; pupal period 14 to 19 days; adult July.

Description: I. Head light brown; body light brown; middorsal, wide brown line; narrow brown line in subdorsal region; subventral line wide, brown. H.W., 0.34 mm; B.L., 5.5 mm; B.W., 0.4 mm. II. Head light brown with brown herring-bone pattern on lobes. Antenna brown. Body light brown; middorsal stripe grey-brown; brown line in subdorsal; lateral region greenish; fine grey line in each of subventral and adventral regions; midventral, very narrow grey line. Legs and plates concolorous. H.W., 0.48–0.50 mm; B.L., 8 mm; B.W., 0.4 mm. III. Head light grey with much blackish over lobes; white line over each lobe in line with white line in upper subdorsal region on thorax. Body light brown; lines grey: middorsal fine, broken; addorsal, as arc on each anterior abdominal segment; subdorsal, grey, with white line above; subventral, obscure; adventral, conspicuous; midventral, fine. H.W., 0.70–0.73 mm; B.L., 9–14 mm; B.W., 0.7–0.9 mm. IV. Head whitish, with brown herring-bone pattern on lobes; whitish on front of head. Antenna light brown, with lines as in last instar. Anal plate with black middorsal line; prothoracic plate concolorous; legs concolorous, anal with light stripe along it. H.W., 1.04–1.11 mm; B.L., 18–20 mm; B.W., 1.5 mm. V. Head light brown, with brown herring-bone pattern over lobes; clypeus often with brown spot in upper corner, sometimes one in each lower corner as well. Antenna light brown. Body swollen on mesothorax; light yellow-green to brown, with markings darker (Fig. 2). Both plates brownish with dark median line. Legs brown, anal leg with light line along it. H.W., 1.67–1.84 mm; B.L., 25–40 mm; B.W., 1.8–3.0 mm.

Remarks: Description based on larvae collected on west side of Bruce Peninsula, Ontario.

Apparently some species of *Lygris* have four-instar larvae (*L. explanata*) and some have five-instar larvae (*L. molliculata*). *L. testata* L., and *L. xylina* Hulst may, apparently, have four or five instars.

Key to Mature Larvae

1. Head horned (parietal lobes attenuate); on *Vitis, Parthenocissus*, and *Epilobium* 2
 Head normal; larvae with other food plants 3
2. Larvae green *L. diversilineata* Hübner
 Larvae brown *L. gracilineata* Guenée
3. Middorsal line partially connected to addorsal line by transverse bar or dark patch in vicinity of D setae 4
 Middorsal line not connected to addorsal line 6

4. Dark oblique posterior to seta D2 5
 Dark patch posterior to seta D2 *L. xylina* Hulst
5. Dark transverse bar between D2 setae (Fig. 1) *L. explanata* Walker
 No dark transverse bar between D2 setae *L. flavibrunneata* McDunnough
6. Setae D1 and D2 on same dark line 7
 Setae D1 and D2 not on same dark line 8
7. Middorsal line continuous *L. testata* Linnaeus
 Middorsal line not continuous (Fig. 2) *L. molliculata* Walker
8. Oblique dash anterior to seta D1; larvae on *Salix* and *Populus* 9
 No oblique dash anterior to seta D1; larvae on *Ribes* *L. propulsata* Walker
9. A continuous dark line through seta SV3 *L. destinata* Moeschler
 Little or no dark line through seta SV3 *L. flavibrunneata* McDunnough

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ON THE GRAMMAR OF THE NAME *HELIOTHIS* OCHSENHEIMER (NOCTUIDAE)

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In recent works by Hardwick (1958, 1965, 1970), including extensive citation of literature, the subfamily name Heliothidinae is used. Investigation into the classical origin of the genus name *Heliothis,* upon which that subfamily name is based, reveals that it is an aorist passive participle of the Greek verb hēlioō, meaning to lie in the sun, to bask. This derivation is given by Treitschke (1826, p. 215) and is confirmed by Ochsenheimer's citation in parentheses after *Heliothis* of the plural nominative form "*Heliothentes* Hübn."

As a participle, one of the 2 kinds of verbal adjectives in Greek, there will be 3 gender forms. These forms and their form in the genitive case, from which family-group names are formed in the singular number and from which names of parasites and other associated organisms may be formed in the plural as well as the singular number, are as follows:

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		Masculine	Feminine	Neuter
Singular	Nominative	hēliōtheis	hēliōtheisa	hēliōthen
	Genitive	hēliōthentos	hēliōtheisēs	hēliōthentos
Plural	Nominative	hēliōthentes	hēliōtheisai	hēliōthenta
	Genitive	hēliōthentōn	hēliōtheisōn	hēliōthentōn

In classical transcription into Latin, these forms are:

Singular	Nominative	heliothis	heliothisa	heliothen
	Genitive	heliothentis	heliothises	heliothentis
Plural	Nominative	heliothentes	heliothisae	heliothenta
	Genitive	heliothenton	heliothison	heliothenton

Strict application of Article 30.a.i of the International Rules of Zoological Nomenclature requires treatment of *Heliothis* as masculine (column 1, above) and strict application of Article 29 requires use of the stem *Heliothent-* in forming family-group names. This would result in the subfamily name Heliothentinae. This procedure, according to Hardwick's citations, has never been followed.

However, if Article 11.b of the Rules, which states that zoological names "must be either Latin or Latinized," be interpreted strictly, we may consider that the complex Greek participial system was not a part of Latin, except in the case of a few words used as nouns and to be found in Latin dictionaries. We may then consider *Heliothis* as declinable in the way the great majority of Latin nouns in *-is* are declined, viz.:

Singular	Nominative	Heliothis
	Genitive	Heliothis
Plural	Nominative	Heliothes
	Genitive	Heliothium

If this be done, the stem used in forming family-group names will be *Helioth-* and the subfamily name consequently Heliothinae. At any rate, there can be no basis for the insertion of *-id-*.

The matter of gender, however, is something else. Article 30.a.i of the Rules requires a ruling by the Commission to establish the name as feminine, because it is grammatically clearly masculine and only masculine, even though ever since Ochsenheimer its usage has been generally as feminine, probably because the species with adjectival names were originally described in the genus *Noctua*. Meigen (1832, p. 224) even changed the generic name into the feminine from *Heliothisa*.

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Editor's Note: Mr. Steyskal's paper is an illuminating one and we are happy to have it for the *Journal.* I cannot see, however, how Article 11(b) would override Article 29(a) which states: "—if the name of a type-genus—is a Greek or Latin word—the stem is found by deleting the case-ending of the appropriate genitive singular." From a puristic standpoint, the subfamily name should be the Heliothentinae. This, as well as the matter of the gender of *Heliothis* as suggested by Mr. Steyskal, should be submitted to the Commission for a ruling.

VARIATION IN LARVAL COLOUR PATTERNS OF *ITAME RIBEARIA* (GEOMETRIDAE)

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Some geometrid larvae have distinctive colour patterns, others do not; some species of *Itame* are good examples of the former (McGuffin 1956). Dugdale (1961) has shown the importance of infraspecific variation in colour patterns and has suggested that such variation could offset the value of coloration for the separation of species. An opportunity to examine infraspecific variation came in 1968 when a colony of *Itame ribearia* (Fitch) was located on an ornamental species of *Ribes* at Bells Corners, Ontario.

Of the larvae collected the following were preserved in 70% ethyl alcohol: 1 in third instar, 33 in fourth instar and 17 in fifth instar. A small number was reared; these provided head capsules in second, third, and fourth instars and information on changes in colour pattern as the larvae matured.

In the first instar, the head capsule is black; the body is light grey with a black area surrounding the base of each D seta, a subdorsal grey stripe of irregular width, and setae L, SV, and V each with a patch of grey at the base.

In the second instar, the head (3 examined) is light brown with five black patches, one as a bar at base of clypeus and two on each parietal

lobe, one in ocellar area and one on the upper part of the lobe bearing setae P and L (Fig. 1); the third abdominal segment (A3), which is typical of the anterior abdominal segments in this species, is light grey, suffused with yellow and with black or dark grey patch at base of each seta, sometimes with grey line connecting patches at base of SD1.

In the third instar, the head (3 examined) is much the same as that in second instar (Fig. 2); A3 is much the same as in second instar with a large spot bearing setae SD1 and a small spot posterior to former (Fig. 3).

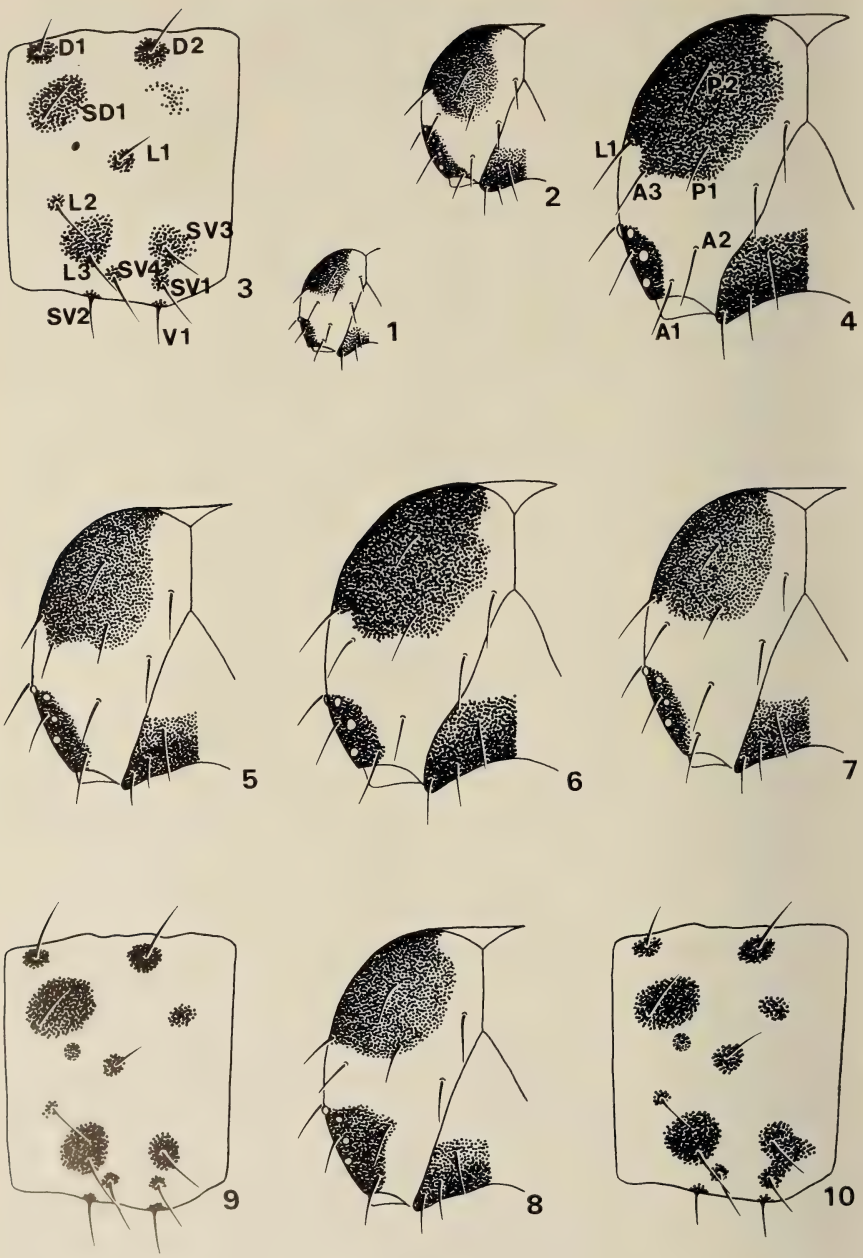
In the fourth instar, five different colour patterns of the head were noted in an examination of 33 larvae and five head capsules. The basic pattern of five spots is present with variation in size of the spots on the parietal lobe. In 17 specimens the patch on the upper part of the lobe included the base of seta A3; in 3 of the 17 the ocellar patch did not include seta A1 (Fig. 4) but in the remainder it did (Fig. 5). In 16 specimens seta A3 was not included in the patch on the upper parietal lobe (Fig. 7) and in 7 of these the ocellar patch included seta A1 (Fig. 6). In one specimen the ocellar patch included seta A2 as well as seta A1 (Fig. 8). On A3 only two distinctly different patterns were noted. The patches bearing setae SV1 and SV3 were separate (Fig. 9) in 16 larvae and connected in 9 larvae (Fig. 10).

In the head capsule of the fifth instar the upper parietal patch was similar in all 17 specimens (Fig. 19) but the ocellar patch in one specimen (Fig. 20) extended out to include seta A1. Eight variations in the colour pattern of A3 have been illustrated (Figs. 11–18) and others have been seen. In all, the subventral stripe is of uneven width and broken or almost broken between setae L3 and SV4 on the one hand and setae SV1 and SV3 on the other.

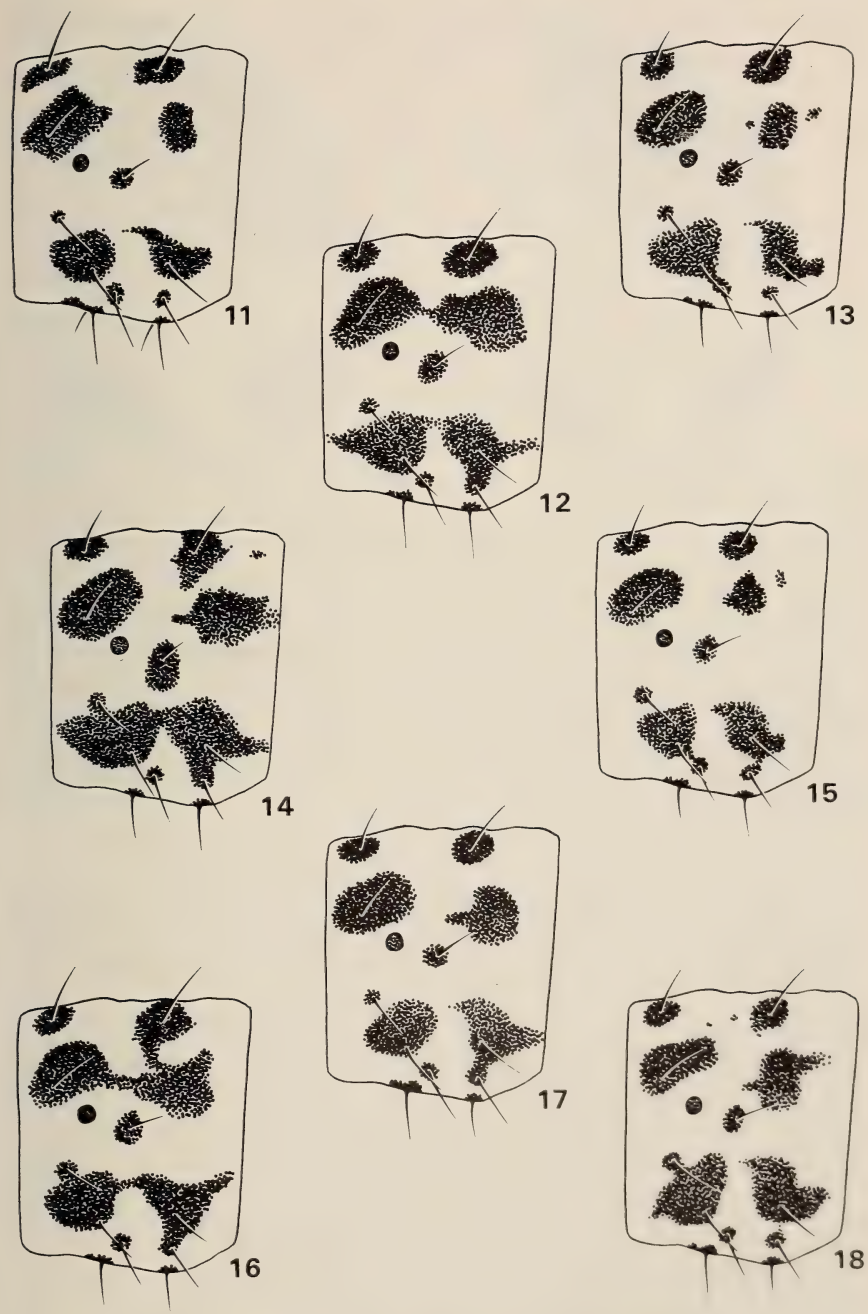
Discussion

This study suggests that the colour pattern of A3 will distinguish mature (fifth-instar) larvae of *I. ribearia* from those of *I. occiduaria* (Packard), *I. evagaria* (Hulst) and *I. andersoni* Swett: the subventral stripe is broken in *I. ribearia* but apparently continuous in the other species (McGuffin 1956). The colour pattern of the head aids in this separation but by itself is too variable to define the species. In *Deilinia* and *Drepanulatrix* (McGuffin 1969) the colour patterns of the head were of more value in separating species than were the colour patterns of the anterior abdominal segments.

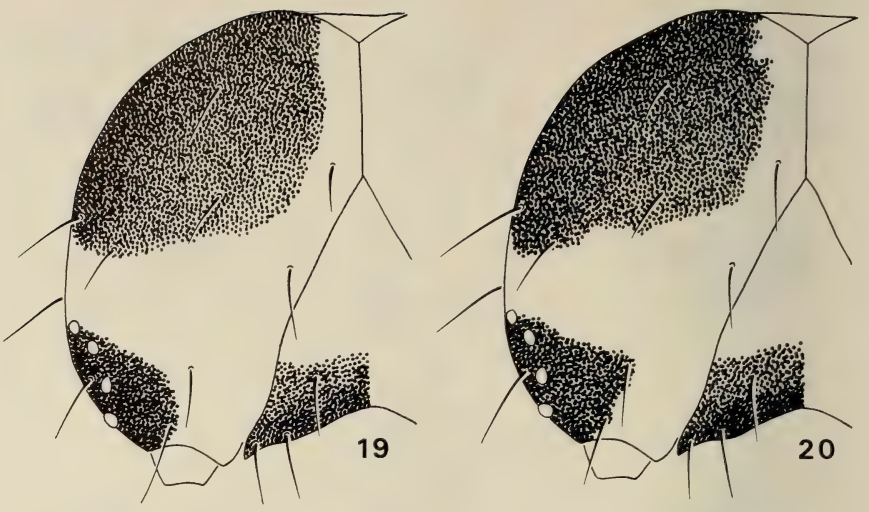
The colour pattern of the head develops from a unicolorous black in the first instar to a five-spotted one in the second and later instars. On the other hand the pattern on A3 changes gradually from the first to the last instar.



Figs. 1–10. Colour patterns of head and third abdominal segment (A3) of *Itame ribearia* (Fitch). 1, Second-instar head; 2, third-instar head; 3, third-instar A3; 4–8, fourth-instar head; 9–10, fourth-instar A3.



Figs. 11–18. Colour patterns of fifth-instar A3 of *Itame ribearia* (Fitch).



Figs. 19–20. Colour patterns of fifth-instar head of *Itame ribearia* (Fitch).

Most of the dark patches on the body of *Itame ribearia* larvae surround setae. However, there is one patch with no seta; this patch lies between setae L1 and D2 on the anterior abdominal segments. It is near the position of seta SDX2 of *Galenara lallata* (Hulst) (McGuffin 1967) and other genera of the Melanolophiini. The dark patch on *I. ribearia* may have no relation to the extra seta in the Melanolophiini but its presence provokes speculations.

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PUPAL COLOR IN *PAPILIO DEMODOCUS* (PAPILIONIDAE) IN RELATION TO THE SEASON OF THE YEAR

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The pupae of some species of Papilionidae may be either green or brown. Green pupae match a green leafy background extremely well, indeed their pattern is suggestive of a curled green leaf, while brown pupae match a dead brown leaf. Brown pupae are rather more variable (some are light and others dark brown) than green, which suggests that the color is cryptic as brown vegetation is more variable in color than green.

The existence of two distinct phenotypes in a population is suggestive of genetic polymorphism under the control of one pair of alleles with dominance. But this is evidently not so in the pupae of Papilionidae as the number of green and brown pupae resulting from a given cross does not fit any known segregation ratio. A typical result is for almost all the pupae to be one color and one or two the other color. In *Papilio demodocus* green × green crosses have given some brown pupae and brown × brown crosses some green pupae. These results cannot be explained by the existence of a pair of alleles with dominance as either green or brown would have to be homozygous recessives and would give only one pupal color among the offspring. It therefore appears that pupal color is environmentally determined, although there may be a genetic component to the capacity to produce a pupa of a particular color.

One possibility is that green pupae tend to be produced when the larvae pupate on a green background and brown pupae when on a brown background. There is some evidence of this which will be discussed later, but in addition there is evidence of a seasonal cycle in the production of green and brown pupae.

On the assumption that green and brown pupae are environmentally determined an experiment was planned to determine if the season of the year affected the frequency of the two pupal colors. There are *a priori* reasons for supposing that green pupae would be advantageous in a tropical wet season and brown pupae in a dry season. It was possible to perform the experiment in both West Africa and East Africa at localities that are quite different in climate. The species chosen for investigation, *Papilio demodocus*, is a common African butterfly. The larvae now feed on *Citrus*, which is an introduced plant in Africa, but some larvae may still be found on the presumed original foodplants, various wild species of Rutaceae.

TABLE 1. Mean monthly rainfall (in mm) at Kampala, Uganda, and Freetown, Sierra Leone.

	J	F	M	A	M	J	J	A	S	O	N	D
Kampala	64	53	139	174	95	61	51	111	98	121	115	96
Freetown	6	1	11	60	180	382	803	849	600	290	110	28

Methods

First and second instar larvae were collected in the wild on *Citrus* and reared in small glass jars, one or two larvae to each jar. When full grown they were allowed to pupate on the side of the jar, but not on the food-plant. The jars were placed indoors and the larvae were reared under normal conditions of temperature, but a very high humidity (near 100%) was generated and maintained inside the closed jars by the larvae and the plants. Larvae were collected and reared in all months of the year. The experiment was conducted in two parts, the first at Kampala, Uganda, in 1964–65, and the second at Freetown, Sierra Leone, in 1968–69. Both these localities have an equatorial climate, but differ in that in Uganda there is some rain in all months of the year with two seasonal peaks, while at Freetown there is a very large single peak of rainfall and a rather severe dry season. The mean monthly rainfall figures (ten-year averages) are shown in Table 1. The most important ecological difference between the two localities which results from the seasonal distribution of rainfall is that Kampala is relatively green all the year round while at Freetown the dry season causes a considerable dying back of the vegetation and the environment is for several months quite brown.

In addition to the main experiment some larvae were reared in the dark in blackened jars and some were reared at high densities, but the results are ambiguous and are not discussed further.

Pupal Color and the Season of the Year

In Table 2 the pupae obtained during the experiments are divided into two groups corresponding to the six wettest and six driest months at Kampala and to the wet and dry season at Freetown. Just over 66 per cent of the pupae at Kampala were green and there is no seasonal difference. But at Freetown green pupae were significantly more frequent in the wet season and brown in the dry season ($\chi^2 = 32.4$, $P < 0.001$). In the dry season just over 39 per cent were green while in the wet season nearly twice as many were green. Since the larvae were forced to pupate on the sides of the glass jars there is no question of matching the background and it appears that there is a built-in seasonal cycle in the frequency of green

Table 2. Relative frequency of green and brown pupae in *Papilio demodocus* reared under controlled conditions at Kampala, Uganda, and Freetown, Sierra Leone.

	green	brown	% green
Kampala			
Six driest months (Dec.-Feb., May-Jul.)	28	14	66.7
Six wettest months (Mar.-Apr., Aug.-Nov.)	43	22	66.2
Freetown			
Dry season (Nov.-Apr.)	48	74	39.3
Wet season (May-Oct.)	89	28	76.1

and brown pupae at Freetown, which, however, does not occur at Kampala.

In November 1970 at Freetown 16 larvae were reared in a cage containing a pot of growing *Citrus*. Six pupated on the plant and all formed green pupae, while the remainder pupated on the wooden lid of the cage and produced brown pupae. The sample is rather small but the result is suggestive that pupal color is correlated with the background on which the larvae pupate.

Discussion

The results obtained suggest that the color of *Papilio demodocus* pupae is adapted to the background color on which pupation takes place, and that in an area where there is a conspicuous seasonal change in the background color there is a corresponding cycle in the frequency of green and brown pupae. Exactly how the cycle is generated is obscure. The dimorphism appears to be largely environmentally controlled but this of course does not exclude the possibility that there are genes that affect larval behavior. It is possible to postulate a switch mechanism which acts on the larva in response to the background on which it is pupating, but in addition there may at Freetown be a seasonal cycle in larval behavior such that more seek out green backgrounds in the wet season than in the dry. On the other hand there are more green backgrounds available in the wet season and thus the probability of a larva pupating on green is increased.

Further investigation is required, especially as other species of Papilionidae also produce green and brown pupae (at Freetown, *Papilio nireus* and *Graphium policenes*), while there are evidently species in which the dimorphism is absent; thus all the pupae of *Papilio dardanus* at Freetown seem to be green.

Summary

The green and brown alternative pupal colors in the butterfly, *Papilio demodocus,* appear to be environmentally determined. Larvae reared under controlled conditions in Uganda produced about two-thirds green and one third brown throughout the year, but in Sierra Leone green pupae were more frequent in the wet season and brown in the dry. The difference between the two localities is correlated with differences in the seasonal distribution of rainfall and its effect on green and brown background colors. There is some evidence that green pupae are formed on green backgrounds and brown pupae on non-green backgrounds.

THE LIFE HISTORY OF *SCHINIA LIGEAE* (NOCTUIDAE)

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Schinia ligeae (Smith, 1893, p. 331) feeds in the larval stage on the blossoms of the Mojave Aster, *Machaeranthera tortifolius* (Gray) (Figs. 2, 4). According to Munz (1963), *tortifolius* occurs on the Mojave and northern Colorado deserts of southern California and is distributed from there eastward to southwestern Utah and western Arizona.

Specimens of *Schinia ligeae* in the Canadian National Collection were taken in various localities on the northern Colorado Desert and the Mojave Desert except for one specimen taken in the Valley of Fire in southern Nevada and another at Ehrenberg, Arizona. The distribution of the moth, therefore, may well correspond with the distribution of its host plant.

Schinia ligeae is a spring-flying species and its flight is co-ordinated with the early blossom period of its host plant. Specimens examined were taken between the middle of March and the end of April.

Behaviour

Schinia ligeae is a predominantly nocturnal species and the eggs are deposited at night in the heads of the Mojave Aster. The eggs are inserted among the florets from the upper surface of the head, usually at a stage when the individual florets of the blossom have not as yet opened. On the basis of the few eggs observed throughout the incubation period, eclosion usually occurs on the fifth day after deposition. The newly hatched larva bores into an adjacent floret and feeds within it for the duration of the first stadium. The second-stadium larva feeds in the head

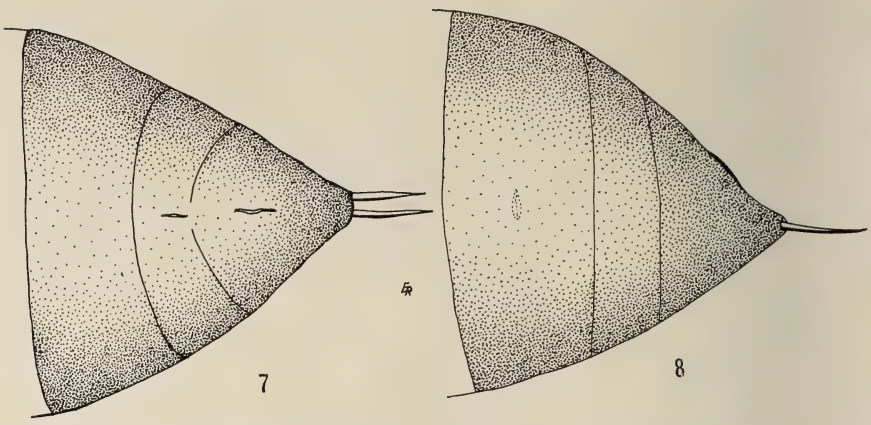


Figs. 1–6. *Schinia ligeae* (Smith), its habitat and food plant. 1, Adult, Desert Hot Springs, Calif.; 2, Fan Hill Wash near Desert Hot Springs where eggs and larvae were found abundantly in the heads of Mojave Aster; 3, ventral aspect of pupae; 4, food plant, *Machaeranthera tortifolius* (Gray); 5, 6, fourth-stadium larvae.

from a position between the florets. Early in the fourth stadium the larva may leave the first head and bore into a second, which it attacks from the top. The larva remains concealed within the aster heads throughout its period of feeding. The fully fed larva makes its way to the ground and tunnels into the soil to pupate. All individually reared larvae matured in four stadia.

Description of Stages

The few gravid females taken in southern California did not oviposit readily in captivity and the developmental data recorded here were based



Figs. 7, 8. Apical abdominal segments of pupa. 7, Ventral; 8, right lateral.

largely on individuals dissected as eggs from the heads of Mojave Aster at Fan Hill Wash near Desert Hot Springs, California. Larvae were reared individually at room temperature using the techniques outlined by Hardwick (1958). The estimate of variability following the mean for various values is the standard deviation.

Adult (Fig. 1). Head and thorax pale fawn-grey. Abdomen fawn-grey or occasionally smoky-grey. Forewing pale grey marked with light fawn. Transverse anterior line white, usually smooth, acutely excurved. Basal space light fawn, usually becoming paler toward base of wing. Transverse posterior line white, inconspicuously scalloped between veins, shallowly excurved around cell, then straight to inner margin. Median space whitish-grey. Orbicular and reniform spots absent. Subterminal space narrow, concolorous with basal space. Terminal space cream. Often a series of indistinct intervenal dashes at margin of wing. Fringe concolorous with terminal space. *Hind wing* light to dark smoky-brown. An indistinct discal lunule and outer-marginal band sometimes evident. Fringe white with a yellowish basal line. *Underside* of forewing with basal and median areas uniform chocolate-brown; outer and apical areas of wing dull cream. Hind wing dull cream, usually with an evanescent discal lunule.

Expanse: 26.9 ± 1.6 mm (62 specimens).

Egg. Pale cream when deposited, becoming suffused with pink on day after deposition. Pink darkening to an orange-brown during next few days; anterior half of egg darker than posterior half. Egg becoming grey, then head capsule becoming visible through chorion a few hours before hatching.

Dimensions of egg: length, 1.55 ± 0.08 mm; diameter, 0.87 ± 0.06 mm (25 eggs).

First-Stadium Larva. Head varying from medium orange-brown through smoky-brown to blackish-brown. Prothoracic shield smoky-fawn to dark smoky-brown. Suranal shield similar in colour but usually paler. Trunk translucent yellowish-grey in newly hatched larva with purplish gut showing through; older larvae cream to light yellow. Spiracles with dark-brown rims.

Head width: 0.518 ± 0.017 mm (25 larvae).

Duration of stadium: 4.5 ± 0.6 days (39 larvae).

Second-Stadium Larva. Head light to medium orange-brown, often mottled

dorsally with smoky-brown. Prothoracic shield varying from light orange-brown to fawn; variably suffused with dark smoky-brown, often heavily so; a pale median line often evident on shield. Suranal shield paler than prothoracic shield. Trunk varying from cream to light yellow. Spiracles with medium- or dark-brown rims. Thoracic legs fawn, variably suffused with smoky-brown.

Head width: 0.864 ± 0.031 mm (25 larvae).

Duration of stadium: 3.4 ± 0.7 days (39 larvae).

Third-Stadium Larva. Head bright orange-brown, suffused and mottled with smoky-brown. Prothoracic shield black, margined with fawn or smoky-brown, and with a narrow median line of pale grey or light cream. Suranal shield varying from fawn-grey to orange-brown. Trunk greyish-cream, without maculation except for increased transparency over heart. Spiracles with black rims. Thoracic legs varying from light fawn to pale orange-brown and suffused with smoky-brown.

Head width: 1.41 ± 0.07 mm (25 larvae).

Duration of stadium: 3.7 ± 0.7 days (39 larvae).

Fourth-Stadium Larva (Figs. 5, 6). Head bright orange, almost indiscernibly mottled with light orange-brown. Prothoracic shield varying from fawn to light orange-brown, with a black or smoky-brown submarginal patch on either side and with a narrow, pale yellow, median line. Suranal shield light orange-brown, weakly mottled with smoky-brown. Trunk various shades of grey, usually slate-grey on entering stadium but becoming paler with increasing size; trunk assuming a dull reddish tone on dorsum as larva approaches the prepupal phase. Spiracles with black rims. Thoracic legs varying from dull yellow to light orange-brown.

Head width: 2.09 ± 0.12 mm (8 larvae).

Duration of stadium: 6.3 ± 1.4 days (39 larvae).

Pupa (Figs. 3, 7, 8). Mahogany-brown, suffused with olive on proboscis and thoracic appendages. Spiracles on segments 2, 3 and 4 borne in shallow oval depressions; spiracles on segments 5, 6 and 7 borne in noticeably deeper pits. Spiracular sclerites moderately broad. Anterior marginal area on each of abdominal segments 5, 6 and 7 strongly sclerotized and raised into a rounded, prominently pitted ridge. Proboscis terminating a short distance anterior to apexes of wings. Cremaster usually consisting of two rather short setae borne at the narrowly rounded apex of the tenth abdominal segment; a few pupae with a short slender seta lateral to each of the median pair.

Length from anterior end to posterior margin of fourth abdominal segment: 8.9 ± 0.4 mm (24 pupae).

Acknowledgments

I appreciate the assistance of Mr. John E. H. Martin, Entomology Research Institute, in providing the photographs for this paper, and of my associate Mr. Eric Rockburne in measuring larval structures and in drawing the cremaster area of the pupa.

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INTER-SPECIFIC HYBRIDIZATION BETWEEN LIMENITIS ARTHEMIS ASTYANAX AND L. ARCHIPPUS (NYMPHALIDAE)

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The Nearctic genus *Limenitis* (Nymphalidae) contains five common, geographically widespread forms, all of which are polytypic, and exhibit tendencies toward hybridization (Edwards, 1879; Scudder, 1889; Field, 1904; Gunder, 1934; Remington, 1958, 1968; Gage, 1970). Four of the forms are mainly allopatric in their distributions, occupying adjacent regions, and coming in contact only along certain margins of their ranges (Hovanitz, 1949). Included among these are two conspecific eastern forms: the banded purple (*L. arthemis arthemis* Drury) and the red-spotted purple (*L. arthemis astyanax* Fabricius), an unbanded mimic of the blue swallowtail (*Battus philenor L.*). In addition, there are two western disruptively banded species: Weidemeyer's admiral (*L. weidemeyerii* Edwards) and Lorquin's admiral (*L. lorquini* Boisduval).

These four forms are closely allied, and conform well to Mayr's (1963) definition of a "super-species." The two subspecific eastern butterflies exhibit "free-interbreeding" and complete intergradation within the northeastern United States and southern Ontario (Edwards, 1877; Field, 1910; Hovanitz, 1949; Platt and Brower, 1968; Remington, 1968; Platt, Frearson, and Graves, 1970), whereas, the two western species exhibit "suturing" and "intense" interbreeding in certain restricted localities, often associated with mountain passes (Brown, 1934; Perkins and Perkins, 1966; Perkins and Perkins, 1967; Remington, 1968).

The fifth form is the predominantly orange-colored Viceroy (*L. archippus* Cramer). It is broadly sympatric with all four of the others and represents a distinct species having: a) evolved a mimetic color-pattern closely resembling the unpalatable monarch (*Danaus plexippus* L.), b) possessing highly modified male claspers (Scudder, 1889; Nakahara, 1924; Chermock, 1950; Platt, Frearson, and Graves, 1970), and c) being, in part, at least, ecologically isolated from the others, preferring open marshy meadows to woods-meadow ecotones and woodland glades.

The purposes of this report are: first, to document the occurrence of a recently collected wild hybrid between the two mimetic species, *L. a. astyanax* and *L. archippus*; second, to review previously known records of such inter-specific wild hybrids in order to verify the scarcity and wide geographic distribution of such specimens; and, third, to present a pre-



Fig. 1. Wild-caught hybrid male (form *rubidus* Strecker) from Durham, N. C. with parental species; top row dorsal, bottom row ventral. Left, *Limenitis archippus*; middle, hybrid form *rubidus*; right, *Limenitis arthemis astyanax*.

liminary report of recent laboratory crosses which confirm the hybrid nature of these intermediate "suspected" wild hybrids.

The new hybrid specimen (Figure 1) is a male, collected on Highway 751, eight miles south of Durham, Durham County, North Carolina, on October 10, 1970 by J. C. Greenfield, Jr.[1] It can be referred to hybrid form *rubidus* Strecker, in that its basic ground color is orange like that of *archippus* but the dorsal surfaces of the forewings are darkly pigmented, whereas, the hind wings possess large red-orange marginal spots. Ventrally, both the proximal and marginal red-orange spotting and remnants of the double row of marginal iridescent lunules characteristic of *astyanax* are present. Both parental species fly commonly in the fields and woods surrounding the vicinity where the specimen was secured.

Other known records of wild hybrids between butterflies of the *L. a. arthemis-astyanax* complex and *L. archippus* are given in Table 1. By reviewing the literature, and corresponding with museum curators and Society members, a total of eight records of wild *arthemis* × *archippus* hybrids (form *arthechippus* Scudder), and 12 previous reports of wild-caught *rubidus* have been found. The wild specimens are widely distributed, but exceedingly rare, those reported in Table 1 having been collected from 1872–1970. Insofar as is known, all wild specimens collected to date have been males.

[1] This specimen has been donated to the collection of the American Museum of Natural History in New York.

TABLE 1. Records of 20 previous wild-caught *Limenitis arthemis astyanax* × *L. archippus* hybrids. Dashes indicate that information was not available.

LOCALITY						
State or province	County	Township	Date	No. and Sex[1]	Collector or Col'ection	Source
	L. a. arthemis × *L. archippus* (*arthechippus* Scudder)[2]					
Quebec	——	Chateauguay Basin Vic. Montreal	1879	1 ♂	J. G. Jack	Edwards (1882)
Maine	Penobscot	Passadumkeag	"many yrs. ago" (2nd brood)	1	L. P. Grey	Grey (1968)
New Hampshire	Cheshire	Alstead	1895, 1896, 1902 (seen)	3 ♂ ♂	W. L. W. Field	Field (1904)
Manitoba	——	Beulah	VI.29.1904	1 ♂	A. J. Dennis	Gunder (1934)
New York	Tompkins	Dryden	VIII.6.1967	1 ♂	A. M. Shapiro	Shapiro and Biggs (1970)
New York	Albany	East Berne	VIII.8.1938	1 ♂	E. Statsinger	F. H. Rindge
Total				8		
	L. a. astyanax × *L. archippus* (*rubidus* Strecker)[3]					
Pennsylvania	Berks	——	Prior to 1872	1 ♂	T. L. Mead	Gunder (1934)
Pennsylvania	Westmoreland	Jeanette	——	1	Barnes Coll.	" "
Massachusetts	Norfolk	Wellesley	——	1 ♂	A.M.N.H. Coll.	" "
Massachusetts	Middlesex	Sherborn	VIII.1896	1 ♂	A. L. Bablock	" "
New York	——	Brooklyn	IX.9.1913	1	Barnes Coll.	" "
New York	"Eastern" (Catskills?)	——	——	1	——	Shapiro and Biggs (1970)
New York	——	Long Island	——	1 ♂	Jacob Doll	Field (1904)
Kentucky	Jefferson	Louisville	IX.1948	1	R. Steilberg & J. Smith	Monroe (1953)
Arkansas	Pulaski	Rose City	IX.1.1933	1 ♂	A.M.N.H. Coll.	F. H. Rindge
Nebraska	Platte	Columbus	IX.4.1963	2 ♂ ♂	E. A. Froemel	K. Johnson
Texas	Bexar	San Antonio	IX.22.1970	1 ♂	J. F. Doyle III	J. F. Doyle III
Total				12		

[1] Insofar as is known, all specimens collected to date have been males.

[2] Eight male *arthechippus* were reared by Field (1914) from an *L. archippus* ♀ × *L. a. arthemis* ♂ cross. Other reciprocal crosses have been made recently by Platt.

[3] A ♀ *L. a. astyanax* × ♂ *L. archippus* were collected *in copula* VIII. 26. 1957 in a barnyard by Mrs. H. E. Hanna at El Dorado, Union Co., Arkansas. The two specimens are in the AMNH (Dr. F. H. Rindge pers. comm.).

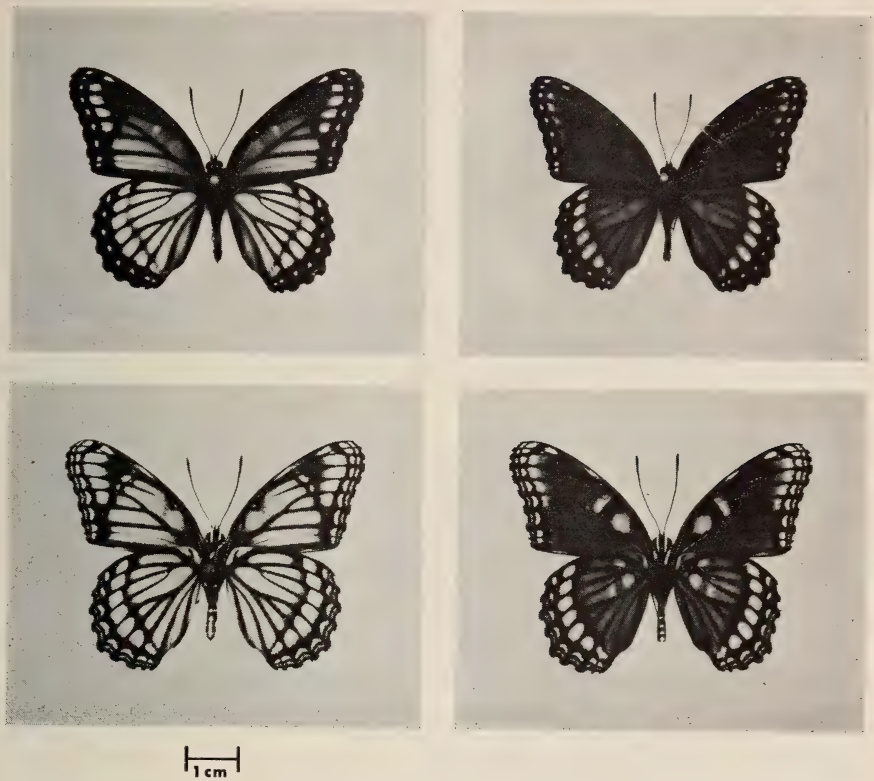


Fig. 2. Lab-bred F_1 *L. arthemis astyanax* × *L. archippus* hybrids; top row dorsal, bottom row ventral. Left, light (*archippus*-like) form; right, dark (*astyanax*-like) form. Specimens bred from Maryland stocks in January, 1970.

Proof of the hybrid nature of *rubidus* requires experimental crosses between the two parental species. As noted in Table 1, there is at least one record of *astyanax* and *archippus* having been collected *in copula* in the natural environment. Such hybrid crosses recently have been made by Platt (Figure 2) by hand-pairing the insects (Platt, 1969), and earlier ones are known to have been done at Yale University (C. L. Remington and R. W. Pease Jr. personal communication). To date, seven fertile crosses have been obtained by Platt. Since these data will be reported in greater detail later, only a brief report of the findings will be included here.

Five crosses between *astyanax* females and *archippus* males have produced a total of 52 F_1 male progeny. Two crosses between *archippus* females and *astyanax* males have yielded 78 F_1 males, for a combined total of 130 F_1 males. As shown in Figure 2, the inter-specific hybrids occur in both light (more *archippus*-like) and dark (more *astyanax*-like) morphs.

the wild-caught specimen described above being of the darker variety (Figure 1). In contrast to *arthechippus* hybrids, all *rubidus* entirely lack the partial white band markings on their dorsal surfaces. However, some, but not all, have traces of the white band persisting in the costal regions of the forewing, as does the recent wild-caught specimen. Such white markings are more fully expressed in *archippus*, but similar markings also are found in certain individuals of *astyanax* (Clark and Clark, 1951; Platt and Brower, 1968).

The complete documentation of *rubidus* as an interspecific hybrid is shown by the fact that all bred F_1 specimens obtained to date are males. Complete heterogametic (female) inviability is encountered when the two full species are hybridized, in accordance with Haldane's Rule (Stebbins, 1958; Bowden, 1966).

However, recently the *rubidus* hybrids have been backcrossed successfully to both *astyanax* and *arthemis* females, and to *archippus* females, as well, yielding four viable broods having a total of 34 male and 12 female progeny (46 in all). Recovery of some of the females is noteworthy, although the sex ratios are still biased in favor of males ($X^2_1 = 10.52$, $P < 0.1$). Only three males have been obtained so far in two backcrosses to *archippus* females, and breeding experiments are continuing.

Nevertheless, these preliminary broods demonstrate that the F_1 male hybrids are fertile in backcrosses to the parent females. Genetic and phenotypic segregation also is apparent in these crosses, all combinations of which have yielded "parent-like" and "hybrid-like" individuals.

Environmental selection probably is operating against the rare naturally occurring hybrids. Since the two parental species are considered to be Batesian mimics of two totally different unpalatable models, such intermediate morphs become exceedingly poor mimics of either one. The total female inviability encountered in F_1 crosses means that the wild males must have to breed with parental females, if at all. Platt, Frearson, and Graves (1970) have shown that *arthechippus* males possess valvae intermediate in shape between those of the two parent species; the same also undoubtedly is true of *rubidus* males. Consequently, sexual selection and mate choice, in which coloration and courtship behavior likewise are important, would not seem to be favoring the male hybrids.

In conclusion, the rare wild hybrid form *rubidus* Strecker represents a true inter-specific F_1 hybrid arising from "stray" matings between two closely related, but distinct mimetic species, *L. a. astyanax* and *L. archippus*. As such, it illustrates well the breakdown of Batesian mimicry in the natural environment, and the selective elimination of an unfit phenotype.

Acknowledgments

We are indebted to Dr. A. B. Klots and Dr. F. H. Rindge of the American Museum of Natural History for confirmation of the identity of the wild hybrid specimen, and for providing certain information given in Table 1. The assistance of Society members who have corresponded with Dr. Platt about hybridization in *Limenitis* also is gratefully acknowledged.

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IDENTITY OF *PHANETA REFUSANA* (WALKER) WITH DESCRIPTION OF A NEW SPECIES (TORTRICIDAE)

WILLIAM E. MILLER

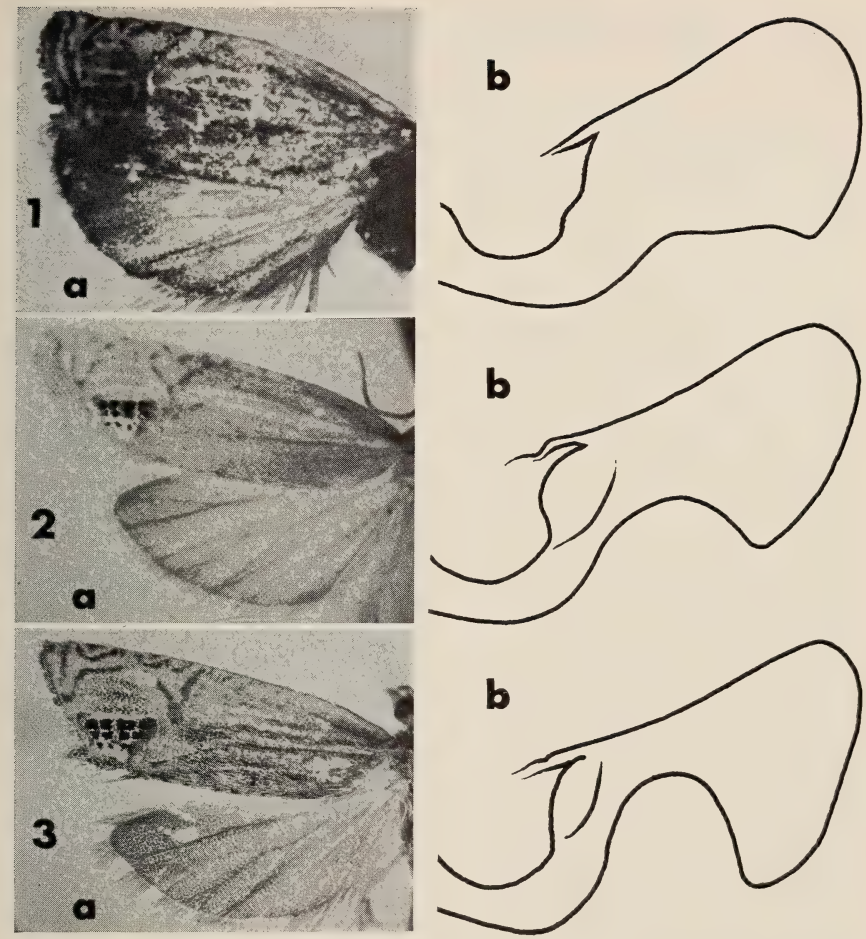
North Central Forest Experiment Station, USDA Forest Service,
St. Paul, Minnesota

The name *Phaneta refusana* (Walker) is currently used for moths matching Heinrich's (1923) idea of Walker's species. Although Heinrich's interpretation is the most explicit available, Heinrich never saw the Walker type. He perpetuated Kearfott's (1905a) identification which was based mainly on Walsingham's (1879) description and lithograph figure. Photographs of the holotype taken by N. S. Obraztsov at the British Museum (Natural History), and made available by the American Museum of Natural History, show that true *refusana* is actually different from the *refusana* of Heinrich. I confirmed this finding by examining the type itself at the British Museum. The misidentified moths have no valid name and I here propose a new one for them.

The letter *n* in this paper signifies the number of specimens observed for a particular statement. Values of *n* differ from the total number studied because all specimens were not satisfactory for all purposes. Forewing lengths (one wing) are given to the nearest 0.5 mm including fringe and excluding patagium. The generic name *Phaneta* is used as suggested by Obraztsov (1952).

Phaneta refusana (Walker), new combination

Grapholita refusana Walker, 1863.
Semasia refusana; Walsingham, 1879.



Figs. 1–3. *Phaneta* spp. 1, *Phaneta refusana,* wings of holotype male as photographed by Obraztsov (a) and Valva of holotype (b); 2, *Phaneta verna,* wings of holotype male (a) and Valva (b); 3, *Phaneta autumnana,* wings of an example from St. Clair Co., Mich (a) and Valva (b).

Walker and Walsingham mentioned one specimen (Fig. 1) which is a holotype by reason of monotypy. The holotype, which is in the British Museum, is labeled "Type H. T.; Hudson's Bay St. Martin's Falls G. Barnston 1844–17; 44 17 St. Martins Falls; *Grapholita refusana* Wkr. . . .TYPE ♂ descr.; 138. *G. . . r.* . . . ; B. M. ♂ Genitalia slide No. 4891." Its forewing measures 7.5 mm. True *refusana* is distinguished primarily by its wide forewing and male valva which has only slight constriction in width (Fig. 1). The species is known only from the type. I have located

no examples in major North American collections nor in the British Museum. It may be a rare boreal species.

Phaneta verna Miller, **new species**

Thiodia refusana; Heinrich, 1923; Kearfott, 1905a; Kearfott, 1950b; McDunnough, 1939, no. 6782; McDunnough, 1942.

Head sordid white. Palpus white except for brown terminus and faint tinge of orange on outer side. Antennal base, collar, and patagium sordid white, partly tinged with yellowish orange. Thorax sordid white except first and second segments which dorsally are light yellow. Legs sordid white, except fore and middle legs which are tinged on outside with brownish yellow and have brown and white banded tarsi. Forewing (Fig. 2a) 8.0 mm, predominantly light yellowish brown, the hue darkening slightly on inner half and at base of fringe. Costa white except for about six faint brown geminations. Outer half of forewing marked with thin silvery gray lines, one of which partly encircles ocelloid area. Dorsal half of ocellus with 10 or 11 regularly arranged black spots, ventral half sordid white due to white-tipped brown scales, and surrounded by light yellow. Fringe speckled due to brown banded white scales. Hind wing mostly white, grading to light brown at outer margin. Fringe mostly white with base light brown and tip edged slightly with gray. Abdomen sordid white. Narrowest width of valva about one-third the greatest width of cucullus.

The description is based on the holotype male which is in the American Museum of Natural History. The holotype is labelled "Criddle Aweme Man. 21V04; Kearfott Col. Ac. 4667; ♂ genitalia V.26.69 Slide 85 C. W. Taylor." The type locality is Aweme, Manitoba, Canada.

Besides the holotype, I studied 17 specimens from localities as follows: MICHIGAN, Oakland, Allegan, and Ingham Counties; COLORADO, El Paso Co.; NEW JERSEY, Middlesex Co.; CONNECTICUT, Windham Co.; ONTARIO, Cochrane Co.; PENNSYLVANIA, Allegheny Co.; NOVA SCOTIA, Kings Co. Forewings ranged from 7.0 to 8.5 mm (13 *n*).

Phaneta verna most resembles and is sympatric with *P. autumnana* (McDunnough). It is tempting at first to think they are spring and fall broods of the same species. This possibility must be ruled out by the color and structural differences summarized below:

Item	verna (*n*)		autumnana (*n*)	
Forewing	Basal half light	(8)	Basal half dark	(11)
Hind wing	Light	(8)	Dark	(11)
Male genitalia	Valva moderately constricted in width (Fig. 2b)	(11)	Valva extremely constricted in width (Fig. 3b)	(18)
Female genitalia	Sternite laterally lobed near fusion with lamella antevaginalis	(5)	Sternite not lobed near fusion with lamella antevaginalis	(3)
Flight period (Michigan examples only)	May 15–29	(7)	Sept. 3–Oct. 13	(21)

Phaneta autumnana (McDunnough), n. comb.

Thiodia autumnana McDunnough, 1942.

This species is illustrated here for the first time (Fig. 3). I studied a total of 25 examples from localities as follows: MICHIGAN, Osceola, Macomb, Livingston, St. Clair, Otsego, Midland, and Shiawassee Counties; WISCONSIN, Oneida Co.; CONNECTICUT, Windham Co. Forewings ranged from 7.0 to 8.5 mm (24 *n*).

Acknowledgment

I thank the following for help with this study: Frederick H. Rindge, American Museum of Natural History; Thomas N. Freeman, Entomology Research Institute (Canada); Jerry A. Powell, University of California; and Paul E. S. Whalley, British Museum (Natural History).

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THE LIFE HISTORY OF *HELIOLONCHE PICTIPENNIS* (NOCTUIDAE)

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Heliolonche pictipennis (Grote, 1875, p. 220) feeds in the larval stage on the Desert Dandelion, *Malacothrix glabrata* (A. Gray) (Fig. 2). In the spring of the year when its food plant is in blossom, the moth often

becomes locally very abundant in some areas of the dry interior of southern California. All the specimens in the Canadian National Collection were taken on the southern California deserts between the middle of March and the middle of May, except for a single specimen taken at Tucson, Arizona, on August 10.

Malacothrix glabrata is an annual composite with yellow blossoms which is recorded (Munz, 1963) as being distributed from southern California northward to Idaho and eastward to Arizona. Whether the Desert Dandelion extends eastward to the Tucson area and if so whether it germinates in response to summer rains in that area is not known.

In the spring of 1955 near Victorville, California, a pair of *Heliolonche pictipennis* was found in copula in the blossom of another annual yellow composite, *Glyptopleura setosula* Gray. It was not determined whether this species constitutes an alternative host plant or whether the association of the moth and the blossom was purely a fortuitous one.

Behaviour

Heliolonche pictipennis is an exclusively diurnal species and in desert areas in which its food plant is abundant and in early blossom, the little moth may usually be found without difficulty flying swiftly from blossom to blossom or resting in the flowering head. When resting or copulating on the head, the moth is usually difficult to discern because it closely resembles the red "button" in the centre of the *Malacothrix* blossom. In the late afternoon the ray petals of *Malacothrix* close upward and inward over the middle of the head and moths that have come to rest on the blossom are thus enclosed until the following day.

The oviposition pattern of *pictipennis* is similar to that of *Heliolonche carolus* described by Hardwick (1969), and the eggs are inserted between the florets from the upper surface of the head. The ovipositing female does not achieve the depth of penetration of the female *carolus*, however, and usually the eggs come to rest among the bristles of the pappus well above the developing seeds.

Four wild-caught females of *pictipennis* deposited a mean of 28.5 eggs, and the maximum laid by a single female was 41. The majority of eggs observed hatched on the fifth day after deposition.

The larva feeds at first on the contents of the florets and subsequently attacks the seeds. During one of the median stadia, the larva usually quits the first head and enters a second in which it completes its development. As with other species of Heliothidinae, the mature larva enters the ground to pupate and it is in the pupal stage that the species spends the greater part of the year.



Figs. 1–4. *Heliolonche pictipennis* (Grote) and plants with which it is associated. 1, Adult, Adelanto, Calif.; 2, its food plant, *Malacothrix glabrata* (A. Gray); 3, pupae; 4, *Glyptopleura setosula* Gray in which a copulating pair of *pictipennis* was found.

Descriptions of Stages

The following descriptions of immature stages were based on the progeny of four females taken in the White Water Pass area north of Palm Springs, California. The larvae were reared individually at room temperature on the flowers and seeds of *Malacothrix glabrata*. Rearing techniques employed were those outlined by Hardwick (1958). The estimate of variability following the means for various values is the standard deviation.

Adult (Fig. 1). Vestiture of head and thorax olivaceous fawn or fawn-grey. Abdomen dark brown with a fawn anal tuft and often with fawn segmental rings. Underside of thorax and abdomen dark brown with varying amounts of fawn over-

scaling. Forewing dull yellow and light fawn marked with pink. Transverse anterior line smooth, weakly excurved. Basal space fawn, variably suffused with pink, most strongly so along inner margin of t.a. line. Transverse posterior line shallowly sinuate, weakly excurved around cell, then usually weakly incurved to trailing margin. Median space dull yellow with a narrow, fawn or pink, costal band. Orbicular spot absent. Reniform spot usually evident as a narrow dark shade. Subterminal space narrow, usually suffused with pink. Terminal space pale olivaceous fawn. Fringe light brown, variably suffused with pink. *Hind wing* black, variably marked with white; white occupying entire central area of wing or reduced to a narrow evanescent median band. Fringe white with a brown basal line. *Underside* of both wings pale grey marked with brown. Forewing with a brown basal dash, narrow reniform spot, and incomplete subterminal band. Hind wing with a brown basal patch, anal patch, and inner marginal band.

A very pale form of *pictipennis* also moderately common in which pink absent, fawn coloring replaced by silvery-grey, and yellow replaced by white.

Expanse: 15.3 ± 1.2 mm (78 specimens).

Egg. Very pale yellow when deposited. Turning somewhat darker yellow on day after deposition, then remaining essentially unchanged until a few hours before hatching when mandibles and then ocelli becoming visible through chorion.

Dimensions of egg: length, 0.919 ± 0.034 mm; diameter, 0.519 ± 0.040 mm (10 eggs).

Incubation period: 4.8 ± 0.4 days (60 eggs).

First-Stadium Larva. Head orange-brown, variably suffused with chocolate-brown. Prothoracic shield fawn, usually heavily suffused with smoky-brown. Suranal shield dark smoky-brown. Trunk pale cream. Thoracic legs smoky-brown. Spiracles with dark-brown rims.

Head width: 0.262 ± 0.012 mm (20 larvae).

Duration of stadium: 3.3 ± 0.7 days (29 larvae).

Second-Stadium Larva. Head smoky-brown. Prothoracic and suranal shields concolorous with head. Trunk greyish-cream, becoming toned with yellow after larva resumes feeding. A dark mid-dorsal band and paler subdorsal areas usually evident. Spiracles with dark-brown rims. Thoracic legs smoky-brown.

Head width: 0.443 ± 0.022 mm (22 larvae).

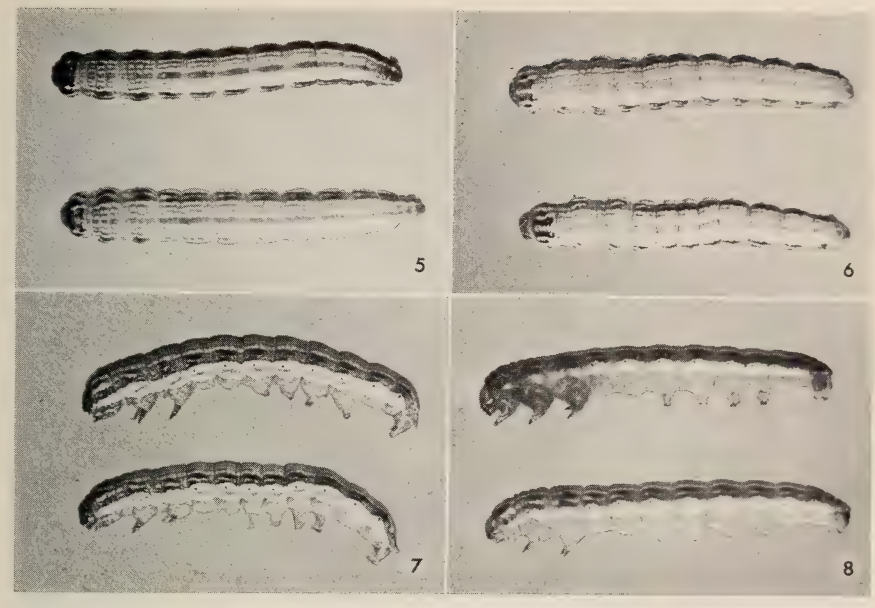
Duration of stadium: 2.4 ± 0.7 days (29 larvae).

Third-Stadium Larva. Head orange-brown, heavily suffused and mottled with dark brown; mottling often so heavy as to almost obscure lighter colouring. Prothoracic shield dark brown with a cream median line, and usually with broader, cream submarginal lines. Suranal shield light orange-brown, variably suffused and mottled with dark brown; usually a pair of cream submarginal lines evident. Mid-dorsal band of trunk varying from light chocolate-brown to orange-brown, and usually with a discontinuous, cream median line. Subdorsal area white or cream with a median orange-brown band; median band paler than mid-dorsal band. Supraspiracular area concolorous with mid-dorsal band, and with a discontinuous, white or cream, median line. Spiracular band white or pale cream with a discontinuous, orange-brown median line. Suprapodal area greyish-fawn, irregularly marked with light orange-brown. Mid-ventral area fawn-grey. Spiracles with dark-brown rims. Thoracic legs dark greyish-brown.

Head width: 0.715 ± 0.024 mm (25 larvae).

Duration of stadium: 2.4 ± 0.5 days (29 larvae).

Fourth-Stadium Larva. Head cream or pale fawn, mottled with orange-brown, and with a few black spots. Prothoracic and suranal shields light orange-brown, variably marked with black; prothoracic shield with three longitudinal white lines, and suranal shield with two longitudinal white lines. Mid-dorsal band of trunk medium chocolate-brown with a pale median shade. Subdorsal area white or cream with a pair of longitudinal lines of orange or light orange-brown. Supraspiracular area medium to dark brown, often darker than mid-dorsal band; with an irregular and



Figs. 5–8. *Heliolonche pictipennis* (Grote), fifth-stadium larvae. 5, 6, Dorsal; 7, 8, left lateral.

discontinuous, pale median line. Spiracular band white with an irregular and discontinuous, orange-brown median line. Suprapodal area varying from orange-brown to medium chocolate-brown, with white arcuate markings. Mid-ventral area yellowish-grey or brownish-grey. Spiracles with dark-brown rims. Thoracic legs pale fawn or pale grey, variably suffused with dark brown.

Head width: 1.14 ± 0.03 mm (25 larvae).

Duration of stadium: 3.8 ± 0.9 days (29 larvae).

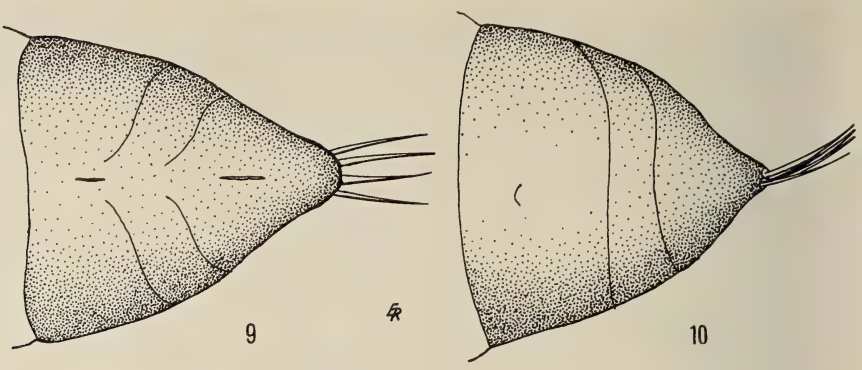
Fifth-Stadium Larva (Figs. 5–8). Head pale fawn or cream, mottled dorsally with chocolate-brown and with several black spots on face. Prothoracic shield fawn suffused with black; in some specimens black suffusion so heavy as to obscure fawn colouring; shield with two or three white longitudinal lines. Suranal shield poorly distinguished from remainder of trunk. Maculation of trunk complex. Mid-dorsal band pale pink, emarginated laterally by irregular lines of brown or red. Subdorsal area white or pale cream with a pair of pale-red, median longitudinal lines. Supraspiracular area brown with an irregular white median line or shade; spiracular band often becoming grey toward posterior margin of each segment and thus with a patchy appearance. Spiracular band broad, white, with a segmentally interrupted, pink or light-red, median line. Suprapodal area fawn-grey, demarked from spiracular band by a light-red line; suprapodal area with an irregular pattern of white and red arcuate marks. Mid-ventral area grey. Spiracles with dark-brown rims. Thoracic legs cream or fawn, lightly marked with chocolate-brown.

Head width: 1.84 ± 0.06 mm (7 larvae).

Duration of feeding phase of fifth stadium: 4.8 ± 1.1 days (29 larvae).

Duration of prepupal phase of fifth stadium: 4.5 ± 0.9 days (15 larvae).

Pupa (Figs. 3, 9, 10). Light brown with a strong green suffusion on head and thoracic appendages. Spiracles on abdominal segments 5, 6 and 7 borne in shallow depressions of cuticle, remainder on a level with general surface of cuticle. Spiracular



Figs. 9, 10. *Heliolonche pictipennis* (Grote), apical abdominal segments of pupa. 9, Ventral; 10, right lateral.

sclerites narrow. Anterior marginal areas of abdominal segments 5, 6 and 7 sparsely and shallowly pitted. Proboscis terminating a short distance anterior to apexes of wings. Cremaster consisting of four slender, elongate, well-spaced setae borne in a single row at narrowly rounded apex of tenth abdominal segment.

Length from anterior end to posterior margin of fourth abdominal segment: 6.4 ± 0.3 mm (19 pupae).

Acknowledgments

I am grateful to Mr. John E. H. Martin of this Institute for the photographs accompanying this paper, and to my associate, Mr. Eric Rockburne, for measuring the immature stages and drawing pupal structures.

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AGUNA CLAXON (HESPERIIDAE) NEW TO THE UNITED STATES

On October 21, 1970, while collecting in the Santa Ana Wildlife Refuge, Hidalgo Co., Texas, I took a single specimen of *Aguna claxon* Evans, a large skipper with green gloss above and with a white band across the secondaries below.

Evans (1952, Cat. Amer. Hesp. B. M.) separated *A. claxon* from *A. coelus* (Stoll). *A. coelus* has the hind wings short-tailed and is less vividly green above. *A. claxon* has the hind wings lobed rather than tailed, and is more brilliantly green above. There are also differences in the male genitalia. According to Evans, *A. coelus* does not occur in Mexico, but ranges from Central America far into South America. *A. claxon* occurs in Mexico and south into Central America, where both species occur.

In Godman & Salvin (1893, Biol. Centr.-Amer. Lep.-Rhop. 2: 287), *A. claxon* appears as *Goniurus coelus* (Cramer). In Hoffman's List (1941, An. Inst. Biol. 12(1): 244) *A. claxon* is listed as *A. coelus* (Cramer). According to Evans, the figures in Seitz, Amer. Rhop., are mixed. Of the figures referred to as *Goniurus caelus* (sic!) Cramer, the underside is stated to be correct. The upper side is that of *Aguna aurunce* (Hewitson).

The specimen of *Aguna claxon* was taken in shade, at the flowers of *Eupatorium odoratum* L., in the heat of the day. On the same plant, a single specimen of *Bolla brennus* (Godman & Salvin) was also taken.

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REMARKS ON "THE USE OF NET-TRAPS AT PALAWAN, PHILIPPINES"

Mr. Jumalon's note under the above heading (1970, *Journ. Lep. Soc.* 24: 303–4) brings out some interesting contrasts between results there and in East Africa.

In East Africa, carnivore dung, that of lion, leopard, civet, etc., is well known for its attraction to many male nymphalids, and man, after all, is mainly a carnivore. It is perhaps worth recording here that the droppings of the domestic dog, although fed largely on meat, do not seem to be attractive.

The usual fruits used as bait in East Africa are banana, pineapple and mango; papaya is mentioned in literature, but I have never found it nearly as attractive as the first three. I have never heard of Custard Apple (*Annona squamosa*) being used as bait.

The trapping of Papilionidae, Pieridae and Hesperiidae is entirely contrary to my experience in East Africa and I am inclined to think that these were cases of low-flying butterflies getting under the edge of the very large net and failing to get out again, a situation analogous, perhaps, to the trapping of birds in mist-nets, rather than attraction to bait.

In East Africa the only species attracted to fruit baits belong to the Satyridae, Nymphalidae (mainly Charaxinae, Nymphalinae and Eurytelinae, with Neptidinae, Vanessinae and Argynnidinae to a lesser extent) and Libytheidae, and males of these species are attracted to faeces.

Almost all families are attracted to damp mud, but again males only. I have very occasionally found female nymphalids on patches of mud but am of the opinion that there is a primary attraction in the form of fermented fruit juices in such cases. The late C. L. Collenette was of the opinion that the major attraction of damp mud was its salt content, and pointed out that the most attractive areas were the banks of streams where clothes were washed or where humans and animals forded streams. Certainly, in my experience, the attraction of damp mud increases with the distance from the sea, it is far more attractive in Uganda than it is on the Kenya coast.

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NOTES ON UNUSUAL SPECIES OF LEPIDOPTERA FROM SOUTHERN FLORIDA

***Danaus eresimus* Cramer.** One worn virgin female was taken while feeding at flowers of *Asclepias curassavica* L. on June 6, 1970 in South Miami, Dade County. Another specimen, a male in nearly fresh condition, was taken at flowers of *Eupatorium serotinum* Michx. on October 6, 1970 near Homestead Air Base in southern Dade County. Both individuals apparently belong to populations of *D. eresimus tethys* Forbes which is common in the greater Antilles.

A search of leaves and flowers of *Asclepias curassavica, A. tuberosa rolfsii* (Britt.) Shiners, and *Sarcostemma clausa* Vail in the vicinity of the capture sites and elsewhere in Dade County yielded only larvae and eggs of resident *Danaus gilippus berenice* (Cramer) and *D. plexippus* L. If *D. eresimus* is established in Florida, it is rare. It is more likely that individuals stray in from the West Indies as suggested by Kimball (1965, Lepidoptera of Florida).

***Urbanus dorantes* Stoll.** This species has recently been reported from southern Florida (Clench, 1970, J. Lepid. Soc. 24: 240–244). *U. dorantes* is well established in Dade County and flies at least between July and April, encompassing three or more broods. From November to January of 1969 and 1970, *U. dorantes* and *U. proteus* L. could be taken with equal frequency in Coral Gables, South Miami, and in sawgrass marshes near Pinecrest, Monroe County. Females of *U. dorantes* oviposit on *Desmodium tortuosum* (Sw.) DC as do *U. proteus* females.

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DANAUS PLEXIPPUS (NYMPHALIDAE) ATTACKING RED-WINGED BLACKBIRD

Last summer, Mr. James Erickson and I were collecting female monarchs, *Danaus plexippus* L., in order to establish a laboratory culture for our study of larval feeding efficiencies. On July 6 and 7, 1970, we were collecting in a large (approximately 10 acres), rather pure stand of milkweed, *Asclepias syriaca* L., at the Ithaca, New York old airport (Tompkins Co.). In one corner of the stand we were constanly harassed by a male red-winged blackbird, *Agelaius phoeniceus* L., on whose nesting territory we were apparently trespassing. In three separate instances we saw a male monarch "attack" the red-winged blackbird as it hovered over us at a height of some 20–30 feet. Flying and diving at the bird for less than a minute each time, the monarch appeared to "frighten" the bird, but although backing off slightly, the bird never left the area. The monarch would break off the encounter and come swooping down to the milkweed patch, flying rather rapidly.

Clark (1931, Butterflies of the District of Columbia) mentioned that male monarchs have been seen to attack smaller butterflies and small birds (i.e., hummingbirds and warblers). The red-winged blackbird eats both seeds and insects, especially beetles, grasshoppers, and caterpillars. The monarchs may have been "flaunting" their warning coloration, although if one assumes that they had fed as larvae on these milkweed plants, they would be palatable to predators because *A. syriaca* lacks cardiac glycosides (Brower, 1969, Scientific American 220: 22–30).

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A SIMPLE METHOD FOR PREPARING MALE HESPERIID GENITALIA FOR EXAMINATION WITHOUT DISSECTION

Examination of the genitalia of Lepidoptera usually involves dissection, a rather unesthetic treatment for a mounted specimen. Evans, in preparing his catalogues of the Hesperiidae, frequently used a dry dissection method, but this is not always totally satisfactory. For the past year I have been extruding the male genital armature while specimens are still fresh by gently pulling on the clasps until the entire armature "pops out." This has not always proved satisfactory because as the specimen dries, the genitalia frequently retract slowly, and in any event, the clasps remain at least partially closed necessitating some tissue rupture to open them for examination of the inner faces and the penis, uncus and gnathos.

Further experimentation has indicated that the clasps can be held in a wide open position during drying by applying a bit of Duco or similar cement, which can be removed later. The technique is as follows:

Holding the fresh insect by the thorax with forceps in normal pinching position, the genital armature can be extruded by gently pulling out the clasps with fine forceps. Sometimes the uncus will be bent down covering and distorting the gnathos; this usually can be teased into a normal position with a dissecting needle. Once the genitalia are fully exposed, grasp the abdomen with fine curved forceps immediately forward of the vinculum which further spreads the clasps. A small quantity of cement is then smeared over the area of the junction of the clasps which are held spread wide with a second pair of fine forceps until the cement dries, 5 minutes or less. I prefer to spread the clasps to a position normal to the abdomen as it simplifies photography. When the specimen is thoroughly dried, either spread or in papers, the cement is easily removed; usually it can simply be peeled away. However, if stuck too firmly, it can be dissolved away by washing in acetone, leaving the genitalia well exposed for study.

The same process also can be applied to relaxed specimens provided the genitalia have been previously extruded, but is not as successful as with fresh specimens. Because of the general structure of the male genitalia of the Hesperiidae, the method is especially applicable to this family though of limited use in others, where for example, details of the anterior portions of the tegumen, the base of the penis or the structure of the saccus are important features. In addition, in several families of butterflies, the genitalia are either too lightly sclerotized or too difficult to extrude to lend themselves to this process.

I sincerely hope that others may find this method as useful as it has been to me.

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CAPTURES OF *ERORA LAETA* IN NORTH CAROLINA (LYCAENIDAE)

Roever (1962, *J. Lepid. Soc.* 16: 1–4) described several records for *Erora laeta* (Edwards) from the southern states. These included a single capture in Tennessee (April 15) and a single capture in North Carolina (July 17). Clark and Clark (1951, *Butterflies of Virginia*) list a single capture in Virginia (June 23) and since that publication at least two additional spring specimens have been taken. There are no recorded specimens from Georgia or northeastern Alabama. All *Erora laeta* taken in the southern states were found in the mountain regions.

On July 1, 1970, I drove from Durham, North Carolina, to Alleghany County in the northwestern corner of the state. I had been in the area a week earlier but rain had cut short my collecting. At that time the *Speyeria* were in good flight and I had made the trip in hopes of getting a nice series of *cybele, aphrodite* and especially *idalia*. I

arrived at my favorite collecting spot (elevation 2700 feet, County Road 1345) about noon but soon discovered that the clover field which had been alive with *Speyeria* the previous week was now very dead. So, I continued down the road in order to check several other spots that had been productive in the past. One such place was a small patch of *Ceanothus americanus* bordering the road. This time I decided to follow the *Ceanothus* over a barbed wire fence and up a steep slope. A few specimens of *Strymon falacer* and *S. titus mopsus* were taken and *Speyeria* females were scattered through the area. Much to my surprise the *Ceanothus* actually covered an acre or more but only a small patch was visible from the road. I worked my way up and down the slope adding a few *Strymon* and *Speyeria* each trip. In addition, two *Strymon liparops* were taken. On one of these trips my vision happened to fall right on an *Erora laeta* sipping nectar in the middle of a large patch of *Ceanothus*! The slope had scattered trees and shrubs on it, but this was the most open part. After staring in disbelief for several seconds (knowing of course that it would disappear forever), I came to my senses and netted the specimen. It was a fresh female! I searched the area thoroughly for the next hour but found no additional specimens. Beech, the supposed foodplant (but why?), was not located near the *Ceanothus* nor in the immediate area. I decided to drive to a location in Ashe County where *S. idalia* was often common. This location (on U. S. 221 near the junction with County Road 1570) is also on a hillside at 2700 feet elevation, but *Ceanothus* is scarce. Instead there is a good colony of *Asclepias tuberosa* and the *Speyeria* were busily flying from one plant to the next. I joined the merriment taking *idalia* and a number of somewhat worn *aphrodite* and *cybele*. Actually *S. aphrodite* was the most common fritillary and a half dozen could be taken off a single flowerhead. At one such clump of orange milkweed I patiently waited for a number of *aphrodite* to settle so that I could maximize my effort. Just when 5 or 6 would settle down, an *idalia* would charge the group and mayhem would result. Finally, in frustration I swung just as an *idalia* was approaching. I quietly cursed at seeing only three *aphrodite* in the net. But, unbelievably there was an *Erora laeta* in with them! Apparently it had been nestled among the *aphrodite* on the flowerhead, and I had taken it unknowingly! This one was a fresh male. Additional searching of the area produced no additional *Erora* nor were beech trees located. Both specimens had been taken on flowers in open areas with scattered trees and shrubs, but in full sunlight. The species is reported to be a denizen of beech forests.

These captures, some 13 air miles apart, may only reflect an extraordinary amount of luck. Smith (1960, *J. Lepid. Soc.* 14: 239–240) took 7 *laeta* in New Hampshire in an area where they had not been found previously. Perhaps both encounters represent local population "pops" (with *laeta* you can't call it an explosion!). Clark and Clark (1951) suggested there might be three broods in Virginia. This seems like a good possibility, but I do not know of any August or September records. Until we know more about the life-history and habits of *Erora laeta,* it will remain a rare species. However, it must be sufficiently common to maintain a breeding population, and I suspect that finding it is only a matter of knowing where to look. Of course having captured two in one day, 13 miles apart, and one by accident, I have given up hope of ever finding another!

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BOOK REVIEW

Butterflies of Trinidad and Tobago. Malcolm Barcant. Collins Publ., London. 1970. 314 pp. + 28 plates. Approximately $6.00.

In the preface, Mr. Barcant states that his book "is prepared in a somewhat new . . . style" that he believes will become popular. I heartily agree that it is a new style, for what other book has divided its subjects by such ambiguous categories as "butterflies of the home garden," "fruit and sap suckers," "migrants," "locals and brooders," "semi-rare species," "species becoming rarer," or "the remaining Lycaenids"? Add to this the fact that there are no keys or alphabetical indexes, and you can imagine the problems of using the text as a field guide. A particular butterfly may be simultaneously a "butterfly of sunshine and flowers" (chapter 6F), "mud-puddle butterfly" (chapter 6D), "migrant" (chapter 6F), "southern resident" (chapter 6I), "well known species" (chapter 9A), "highly prized species" (chapter 9D), "species becoming more common" (chapter 9E), "species with special interests" (chapter 9G), and a "remaining Lycaenid" (chapter 10), but will be discussed under but one of these categories. For Trinidad butterflies, the situation is complicated even further by numerous groups of very similarly marked species. *Papilio thoas*, for instance, is treated as a "home garden butterfly" (page 74) with no cross reference to the almost identical *Papilio homothoas* (a species "becoming rarer" on page 188) or to the similarly marked *Papilios androgeus* and *lycophron* ("water drinkers" on page 92). For somebody unfamiliar with Neotropic butterflies, the only way to identify a specimen with complete assurance would be to read the entire book. I do not share Mr. Barcant's hope that this style of book will become more popular.

There is, however, quite a bit of excellent information in the book. Mr. Barcant has collected on Trinidad for many years and his comments on the habitat and habits of each species should be of considerable value to the student of Neotropical Lepidoptera, as should the citations of larval foodplants. One chapter deals with "flowers popular among adult nectar-sucking butterflies," which, aside from the practical collecting aspects, is valuable information to have recorded. Another section deals with collecting localities and seasons on Trinidad and would be of considerable value to somebody planning a collecting expedition to the island. Nearly all of the Trinidad species, excluding Hesperiidae, are satisfactorily reproduced in color plates, with however, a reduction in size and no scale or other indication of actual size cited.

Aside from its general deficiency as a field guide, the book has a number of other weaknesses. Typographic errors, especially in the latin names of species, are frequent, e.g. *Anteos clorinde* is consistently cited as *"chlorinde"*, *Papilio lycophron* as *"lycrophon," Heliconius hecale* as *"hecali,"* etc., and it would be impractical to list all of these. There are also a number of erroneous statements such as "each species of butterfly is constant and its sex organs differ in shape from any other species so that mating outside its own female is not possible" or "it is necessary to add brackets to the name of the man who first described the butterfly."

I also believe that Mr. Barcant exercised poor judgement in introducing several species as new. *Pachthone barcanti*, which was described by G. E. Tite in 1968, is introduced as *Sp. Nov.* with no author cited. *Adelpha cytherea insularis* and *Sostrata pusilla manzanilla* are also introduced as *Sp. Nov.* with no author citation. Unless quite recently, these have not yet been published elsewhere and, if this is so, the descriptions in the text constitute original description. I am sure that this was not intended to be the case and I doubt if Barcant was designed to be their author.

A check-list of Trinidad butterflies (chapter 14) is arranged along no phylogenetic order in current use as follows: Satyridae, Danaidae (including *Acraea*), Ithomiidae, Heliconidae, Nymphalidae, Morphidae, Brassolidae, Libytheidae, Papilionidae, Pieridae, Riodinidae, Lycaenidae and Hesperiidae. The generic names used are sadly dated for the Lycaenidae and Hesperiidae, but pretty much in current usage for other families. In the Nymphaloid groups the only readily apparent errors, in this respect,

are the use of *Callicore* for *Diaethria* and, in turn, the retention of *Catagramma* for *Callicore*.

English vernacular names, such as *Flambeaus, Pages, Shoemakers, Crackers, Cattle-Hearts* and others, that are in actual use in Trinidad are recorded, perhaps for the first time. In spite of their lack of scientific value, I find them quite interesting and am glad to see them preserved by publication.

There is much of interest and value in the book; the serious student of Neotropic Lepidoptera may find it a valuable reference. However, it was intended primarily as a field guide and aid for the young collector on Trinidad; a usage for which it has some very serious limitations.

JOHN H. MASTERS, *Lemon Street North, North Hudson, Wisconsin.*

The most serious fault with the book is one that cast a question over all the book contains. There are three names used in the book that are labeled "Sp. Nov." One of these is *Pachythone barcanti* which was described by G. E. Tite of the British Museum in 1968 and certainly Barcant knew that this was not a nameless species to which he was giving a name in this publication. The other two "Sp. Nov." are equally senseless. *Adelpha cytherea insularis* was described by Fruhstorfer in "1915" 1916 in Seitz' *Macrolepidoptera,* 5: 521. Barcant was familiar with this book and used it. *Sostrata pusilla manzanilla* was described by Kaye in 1940 and certainly anyone writing on Trinidadian butterflies must have examined all of Kaye's writings about them. I don't know whether these actions of declaring named species "Sp. Nov." was done in ignorance or with the supposition that no one would bother to investigate.

F. M. BROWN, *Fountain Valley School, Colorado Springs, Colo.*

BOOK REVIEW

THE MOTHS OF AMERICA NORTH OF MEXICO, FASCICLE 21, SPHINGOIDEA, by Ronald W. Hodges. 1971; 158 pp. + i-xii, 14 coloured plates; paper-bound. E. W. Classey Limited and R.B.D. Publications Inc. Distributed in North America by Entomological Reprint Specialists, P.O. Box 77971, Dockweiler Station, Los Angeles, California. Price $24.00 U.S. (Subscription Price $19.60).

This is the first published fascicle of the eagerly awaited series of the North American Heterocera. Dr. Hodges is to be congratulated on his very fine treatment of the 115 species of hawk moths in the boreal American fauna. Under each species heading is given a brief synonymical bibliography, a description of diagnostic structural and macular features, a listing of larval food plants and a discussion of the distribution. Keys to genera and species are presented, and these in most cases seem easy to use. Old keys to genera based on pupae (Mosher, 1918) and larvae (Forbes, 1911) are reproduced in an introductory section. The nomenclature of the various structural characters employed in classification is well explained both in the text and by line cut illustrations. The most outstandingly laudable feature of the volume, however, are the magnificent coloured plates; the specimens are all ready to fly right out of the pages.

This is a book that should be readily available to both the professional and the serious amateur.

D. F. HARDWICK, Editor.

A Field Guide to the Butterflies and Burnets of Spain, by W. B. L. Manley and H. G. Allcard. 1970. 182 pp., 41 colour plates including frontispiece. Publishers: E. W. Classey Ltd., Middlesex, England. (Available in U. S. from Entomological Reprint Specialists, P. O. Box 77971, Dockweiler Station, Los Angeles, California 90007; price $37.50.)

This book includes all 229 species of butterflies known to occur in Spain, and in addition to these, the 26 species of burnets (Zygaenidae). The colourful burnets being diurnal are as popular with collectors as many of the butterflies and their inclusion enhances the usefulness of the book.

The term "field guide" usually carries with it the connotation of a compact volume with detailed and comparative descriptions of the various species but neither of these qualities is found in the "Butterflies and Burnets of Spain." All species are illustrated in beautifully prepared colour plates. In many cases, males, females, undersides, and pattern variations are all reproduced at life size. Unfortunately the page number for the text of the species is not included in the plates and it is necessary to refer to the index to find the text reference for the butterfly. The plates do however include the complete data for each specimen illustrated.

The text for each species is short and usually covers three subjects. These are: the localities where the species may be most easily located, complete with elevation and time of year, secondly, a discussion of the various subspecies and forms described, and thirdly, the larval host plants.

In addition to the butterflies and burnets of Spain, sections at the end of the text deal with the Balearic Islands, the Canary Islands, and Madeira with a similar text and plates.

At the end of the text there is a complete systematic check list of species, subspecies, and forms in the Iberian Peninsula, the Balearic Islands, the Canary Islands and Madeira. The list includes references to original descriptions for a more detailed study of the species.

"The Butterflies and Burnets of Spain" will be an invaluable field guide to collecting as well as identification for the lepidopterist interested in collecting in any of the areas treated in the book.

J. Donald Lafontaine, *916 Innswood Drive, Ottawa, Ontario.*

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Memoirs of the Lepidopterists' Society, No. 1 (Feb. 1964)
A SYNONYMIC LIST OF THE NEARCTIC RHOPALOCERA
by CYRIL F. DOS PASSOS

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VOLUME 25

SUPPLEMENT 1

A NEW GENUS OF HAIRSTREAK FROM CENTRAL AND SOUTH AMERICA (Lycaenidae, Theclinae)

By S.S. Nicolay

10 May 1971

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JOURNAL OF THE LEPIDOPTERISTS' SOCIETY

VOLUME 25

SUPPLEMENT 1

A NEW GENUS OF HAIRSTREAK FROM CENTRAL AND SOUTH AMERICA (Lycaenidae, Theclinae)

Col. S. S. Nicolay, USMC (Ret.)
1500 Wakefield Drive, Virginia Beach, Virginia

Introduction

In a recent issue of the Journal of the Lepidopterists' Society appeared a statement that the taxonomic status of the South American "Theclas" is chaotic (Brown and Mielke, 1967). For those familiar with the tropical Theclinae, this statement comes as no surprise. Indeed, it may be expanded to include most of the tropical hairstreaks of the New World. The purpose of this work is to attempt to clarify the taxonomy of one small segment of the Theclinae (Strymonini) of the American tropics.

At infrequent intervals, I have received small shipments of hairstreaks from a few collectors in South and Central America. Among these, three species were of particular interest; each was represented by relatively good series and included both sexes; each bore an unusual resemblance to the other in size and wing shape, if not in color and pattern. The three species were tentatively identified and placed together as a single group, although they were from two different groups in Seitz (1920). A study of the male genitalia confirmed the validity of the single group concept.

During the past six years I have collected four additional species of this new genus in the Republic of Panama, the Canal Zone and in Colombia and Brazil. Recently, representatives were found in the collections of the Smithsonian Institution, the American Museum of Natural History, and the Carnegie Museum. A single female of a new species was found in a series of miscellaneous accessions in the British Museum (Natural History). Analysis of these 10 species indicates they belong to a distinct and narrowly defined genus, characteristic in size, wing shape and general pattern. The male and female genitalia are very distinctive. These, plus other morphological characters, should make recognition of any additional species relatively easy.

The original descriptions of many of the species treated herein are sketchy. Indeed, the descriptions may be applied to any number of species outside this new genus. Therefore, each is here redescribed and figured. The illustrations were made by the author; the photographs, with the very able technical assistance of SSgt. Robert Prisler, U.S. Marine Corps.

Acknowledgments

My special thanks and appreciation go to Dr. John Downey, University of Northern Iowa, Cedar Falls, for his encouraging critical analysis, many fine suggestions and excellent technical guidance. To Gordon B. Small, Jr., Balboa, Canal Zone, I am particularly indebted for his invaluable assistance in all aspects of the field work, much of which made this study possible. I am especially grateful to Mr. T.G. Howarth and Mr. G.E. Tite, British Museum (Natural History) for their assistance and generosity in allowing me to exam-

ine and study the Druce and Hewitson type material. To Dr. F.H. Rindge, American Museum of Natural History, New York, Dr. J.F.G. Clarke, Dr. W.D. Duckworth and W.D. Field, Smithsonian Institution, and Harry Clench, Carnegie Museum, my thanks for their interest, helpful suggestions and complete cooperation.

In Brazil, Dr. Keith S. Brown, Rio de Janeiro and Dr. Heinz Ebert, Rio Claro provided me with the opportunity to study their large and interesting collections of Brazilian Lepidoptera. To them go my thanks for their hospitality, their many helpful suggestions and enthusiastic encouragement. With Keith Brown I made an incredibly productive and interesting collecting trip into the Mato Grosso. This unique opportunity to collect and work in such a remote area is gratefully acknowledged.

SYMBIOPSIS Nicolay, new genus

Type species: *Thecla strenua* Hewitson, 1877

Hindwing with two tails, the shorter at end of Cu_1, the longer at end of Cu_2. Postmedian line on underside of forewing ending abruptly at vein Cu_2; without cell-end streaks or bars on underside of fore- or hindwing. Postmedian line of hindwing, bipartite, uneven, forming posteriorly a broad angular "W" which terminates at 3A very close to inner margin; middle angle of "W" rounded, extending basad in interspace Cu_2 more noticeably than in other interspaces. Male with no scent spot or other secondary sexual characteristics. Frons with appressed scales and many intermixed erect bristle-like scales; eyes densly covered by short erect hairs; antennae with a 15-segmented stalk, 12 segments on the club.

Male genitalia without a saccus; tegumen extended in a horizontal, dorso-lateral plane, vinculum then curved sharply 90° toward ventral surface; falces viewed from ventral surface, large, sharply angular, with terminal arms tapered to a sharp point; viewed laterally, flattened dorsoventrally, appressed rather close to uncus. Valvae long, 4/5 length of vinculum, relatively narrow, completely separate, with interior surfaces clearly grooved to retain aedeagus; aedeagus stout, evenly tapered to tip, posterior end curved dorsally through approximately 60° in an even sweeping arc, with or without a ventral keel, without cornuti or terminal teeth.

Female genitalia with ductus bursae a complex, stout organ; dorsally composed of two lateral free-moving sclerotized elements, separated almost their entire length, fused into a hollow, sclerotized tube prior to entry into corpus bursae; ventrally composed of a semi-membranous pouch which appears to hold the two dorso-lateral elements together. Ostium guarded dorsally by the two rather heavily spined dorsal plates of ductus bursae; ventrally formed by membranous juncture of seventh and eighth abdominal tergites. Anterior end of ductus bursae rather sharply recurved dorsally through an arc of almost 180° just prior to entry into the corpus bursae; latter a simple, oblong, completely unadorned sac, at least as long as or longer than the ductus bursae.

The name *Symbiopsis* is an arbitrary combination of Latin terms, but without special meaning. I consider it to be of the feminine gender.

Symbiopsis species bear a superficial similarity to many new world tropical hairstreaks. The lack of scent spots and other secondary sexual characteristics, the size, ground color and trace of the postmedian line on the underside of the wings are features common to both *Symbiopsis* and the genus *Calystryma* Field, 1967. Yet there are definite and obvious generic differences between the two. *Symbiopsis* species have no cell-end streaks on the underside of either wing; *Calystryma* species have the cell-end streaks on the underside of both wings. The wing shape of *Symbiopsis* is rounded and full; that of *Calystryma*, more angular, the apex of the primaries more acute, particularly in the male. The male genitalia of *Symbiopsis* has no saccus, the falces are large, sharply angular, the aedeagus is stout with a sweeping dorsal curve, and without cornuti or terminal teeth; that of *Calystryma* always has a saccus, the falces are rather small, not sharply angular and the aedeagus is long, rather slender, usually straight and always with at least a single, spine-like cornutus at or near the terminus. The female ductus bursae of *Symbiopsis* is heavily sclerotized, divided throughout most of its length into two lateral elements and anteriorly recurved dorsally through an arc of nearly 180°, prior to entry into the corpus bursae which is unadorned; that of *Calystryma* is a simple sclerotized tube, not recurved dorsally at the anterior end and with the corpus bursae ornamented by two large, complex signa.

Both male and female genitalia are generically very characteristic but do not offer a panacea for specific determination. The genitalia of both sexes show considerable variation within each species; *e.g.*, the spines of the ostium bursae vary both in size and number in females of the same

species. In this respect, most were found to be markedly asymetric in the number and shape of the spines on each lateral plate. The size and shape varies in much the same way in the male genitalia of a given species, but to a lesser degree. However, the combination of characters provided by the genitalia of both sexes together with those of wing shape, color and maculation make specific determination of both male and female specimens relatively easy and accurate.

Most species of this genus are intensely local. Those we have taken fly very rapidly along chosen paths or narrow roadways skirting the sunny edge of usually heavily wooded areas. Their rarity in collections is understandable for they are not readily attracted to flowers and rest only briefly on leaves. In many cases, they must be taken on the

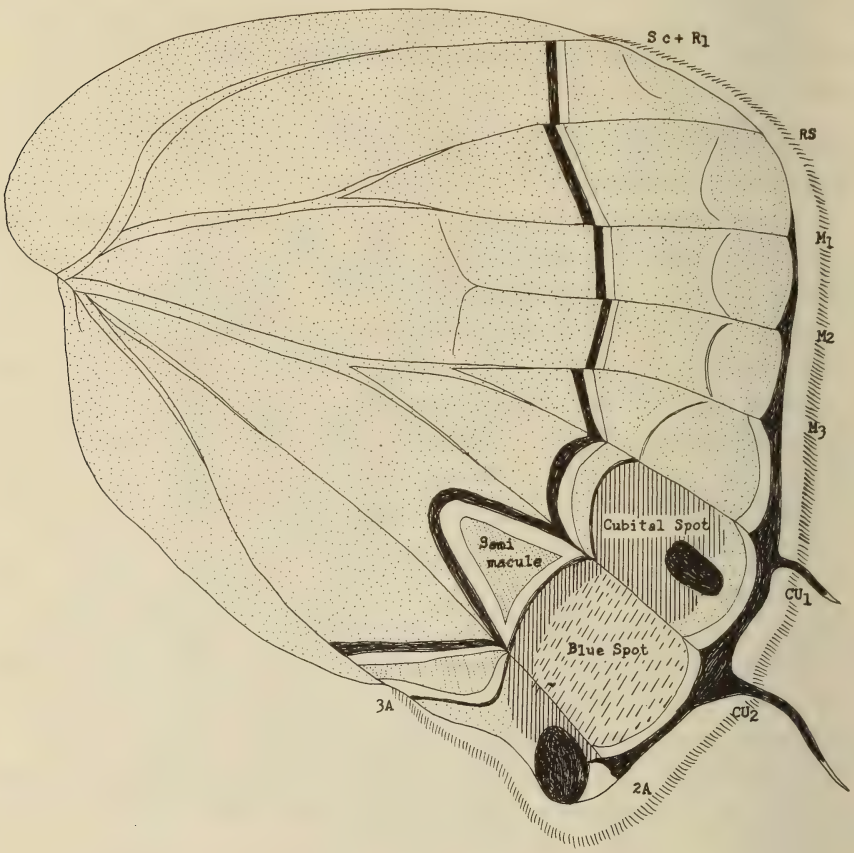


Figure 1. *Symbiopsis* hindwing; stylized sketch of underside maculation pattern

wing. Their swift and erratic flight makes them difficult to see, follow and net.

A stylized sketch of the undersurface pattern of the hindwing of *Symbiopsis* is illustrated in Figure 1. Not all species in the genus have all of the linear features shown, nor do all species follow the exact pattern as illustrated. However, the basic features of the genus are contained in Figure 1 and the nomenclature for the specific macular features is noted on the illustration and used throughout the text and in the key.

Key to *Symbiopsis* species

1 Underside of hindwing without red cubital spot..... 2

Underside of hindwing with red cubital spot..... 3

2 Underside of hindwing without powder blue or grey-blue spot in Cu_2; underside ground color, greyish-white....*lenitas* (Druce)

Underside of hindwing with large grey-blue spots in interspaces Cu_1 and Cu_2.....*tanais* (Godman & Salvin)

3 Underside ground color light greyish-white; cubital spot orange-red, small.....*nippia* (Dyar)

Underside ground color much darker, brown or brownish grey..... 4

4 Upperside of male and female forewing blackish-brown..... 5

Upperside of male and female forewing with lustrous blue scaling..... 6

5 Upperside of forewing and hindwing black-brown with a faint blue-grey tint toward the wing bases; male and female alike.....*pupilla* (Draudt)

Upperside of male hindwing shining lustrous blue with wide dark margins; female brown.....*pentas* Nicolay

6 Upperside wing color lustrous indigo-blue with wide, dark margins..... 7

Upperside wing color greenish steel-blue with narrow black margins..... 9

7 Upperside of forewing mostly dark blackish-brown, the blue confined narrowly in the disc along vein 2A.....*pennatus* (Druce)

Upperside of forewing with the blue expanded and reaching into the cell..... 8

8 Cubital spot of Cu_1 large, red, spilling into space M_3, with a broad bar over the blue spot of Cu_2.....
.....*smalli* Nicolay

Cubital spot of interspace Cu_1 small, dull red, crescentic; no red bar over the blue spot.....
.....*strenua* (Hewitson)

9 Cubital spot orange-red confined primarily to Cu_1, the red bar over the blue spot, narrow.....
.....*panamensis* (Draudt)

Cubital spot very large, deep red, spilling into interspace M_3 to vein M_3; a broad red bar over the blue spot of Cu_2.....*morpho* Nicolay

SYMBIOPSIS STRENUA (Hewitson), new combination

Figure 2; Plate I (Fig. 1 and 2)

Thecla strenua Hewitson, 1877, Illustr. Diurnal Lepid; Lycaenidae, 1:207; 2, pl. 82, figs. 689, 690. Draudt, *in*: Seitz, 1920 Gross-Schmett. der Erde, 5:788, pl. 156, figs. i-9, i-10. Comstock and Huntington, 1963, J. N. Y. Ent. Soc., 71:263.

Type data: "In the collection of W.C. Hewitson, from Brazil".

This species is very similar to many other tropical hairstreaks. The original description is extremely brief and overlooks many features that place *strenua* within this genus. The species is redescribed as follows.

Male: Length of forewing 12.5 mm.

Upperside: Margins of forewings wide and ill-defined, with indigo-blue color confined to discal third of wing, adjacent to inner margin. Margin of hindwings about 1 mm wide, expanded at apex, remainder of wing dull indigo-blue, faintly iridescent; anal lobe spot small, black, centered with orange-red; a marginal black line, inwardly edged in white, beginning at the small tail, tracing outer margin to anal lobe; fringes of same area tipped in white.

Underside: Ground color olive grey-brown; submarginal line of forewing dark brown, lunular and broken at each vein; postmedian line dark brown, distally edged in white, beginning at costal margin and ending abruptly at vein Cu_2. Postmedian line of hindwing dark brown, becoming darker towards anal margin, distally edged in white, rather uneven, beginning at costal margin, then forming a broad angular "W" before terminating at inner margin; submarginal band composed of dark brown crescents between each vein, vaguely bordered on each side by light scaling; cubital spot between tails dull

red, small, crescentic and centered at distal edge with a prominent black spot; the cubital red crescent as wide as ground color between it and the white line proximal to terminal line; the grey-blue spot adjacent in interspace Cu_2 large, quadrate, with a small red bar between it and the small black spot of anal lobe; no other red in interspace Cu_2 except as associated with anal lobe; a marginal black line, inwardly edged in white, beginning at vein M_1 becoming thickest at Cu_2, tracing outer margin to anal lobe.

Female: Length of forewing 12 mm.

Same as male except some variation in the amount of blue on upperside of forewing; usually the pale blue color narrowly confined to the area along inner margin, leaving forewing almost completely dark brown; in early "spring season" (October), Santa Catarina individuals, the blue of forewing not confined to inner margin, extending as a pale wash far into disc and cell, leaving a relatively narrow, vaguely defined dark margin. The dark margin of hindwing slightly wider than in male. Underside as in male.

Symbiopsis strenua has in the past been confused with *Thecla pisidula* Druce, due probably to the Draudt (in Seitz, 1920) illustration of "*pisidula*"; it is a good reproduction of *strenua*. The series of two males and seven females from which the present diagnosis was made was collected by Mr. Fritz Plaumann in Nova Teutonia, Santa Catarina, Brazil, at an altitude of 300-500 meters. The dates of capture are predominantly January through March. Specimens from this series were compared with the Hewitson type material in the British Museum (Natural History).

A study of series of this species in the Brown and Ebert collections provided material basis for a more accurate appraisal of the geographical distribution. This species is found in the forested mountain localities in the states of Minas Gerais, Sao Paulo, Parana, Santa Catarina and to the west in adjacent areas of Paraguay (Villa Rica). Most likely, *strenua* is basically a southwestern species which reaches the northern limit of its range in Minas Gerais (Belo Horizonte) via the tributaries of the Plate River system.

SYMBIOPSIS LENITAS (Druce), new combination

Figure 3; Plate I (Fig. 3 and 4)

Thecla lenitas Druce, 1907, Proc. Zool. Soc. London, : 603, pl. 36, fig. 5. Draudt, *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:788, pl. 156, fig. i-8. Comstock and Huntington, 1961, J. N. Y. Ent Soc., 69:109.

Iaspis violescens Spitz, 1931, Revista de Entomologia, Sao Paulo, 1:48 (*new synonymy*).

Original description:

"Male. Upper side: fore wing uniform dull brown, paler towards centre of disc, inner margin very narrowly dusted with blue. Hind wing pale violaceous blue, with costa, apex and outer margin rather broadly brown; abdominal fold paler brown. Cilia of fore wing brownish, of hind wing white. Underside ground colour uniform pale grey. Forewing: a linear dark ultra-median band, outwardly bordered with white, from the costa to the lower median nervule, followed by a faint submarginal lunular line. A very fine anteciliary dark line. Cilia yellowish grey, darker at the tips. Hind wing: a median linear band as on fore wing but more sinuous, commencing on the costa and reaching to the abdominal margin, followed by a submarginal faint lunular line which becomes more distinct towards the anal angle. A black anteciliary line from the apex to the anal angle broadest at the base of the tails. Cilia pale grey. Tails blackish tipped with white.

Female: Upperside uniform dull brown. Underside as in male.

Expanse: 1 - 1 1/5 inch.

Habitat: Chapada Campo, Brazil (H.H. Smith); Paraguay (Perrens).

Type, Mus. Godman.

A species with no brand or perceptible patch on the fore wing and not allied to any with which I am acquainted but perhaps belonging to the group which contains *T. dindymus* Cr.

Mr. Smith's specimens were captured in January and February."

The original description is excellent. This species is one of the most easily recognized and distinctive of the genus, made so by the lack of typical thecline markings on the underside of the hindwings. There is neither cubital red spot in interspace Cu_1, nor blue spot adjacent thereto in interspace Cu_2. Instead, these are replaced by vague patches of grey scales. The anal lobe spot is very small and black.

Male: Length of forewing, 11.5 mm.

Female: Length of forewing, 11.5 mm.

These notes were made from a series of 12 males and 13 females collected by Mr. Fritz Plaumann in Nova Teutonia, Santa Catarina, Brazil, at an altitude of 300-500 meters. Most specimens were captured during the months of March through June. A single female taken at Caviuna, Parana,

Brazil in April is in the American Museum of Natural History. Specimens from this series have been compared with the type series in the British Museum (Natural History), and with the type of *T. violescens* Spitz which is clearly a synonym of *lenitas*.

In the Brown and Ebert collections, I was able to examine an extensive series of this species, taken in numerous localities in southern Brazil and Paraguay. Essentially, *lenitas* seems to be a species of the wooded watercourses of the Brazilian Planalto. Its currently known geographical range includes the states of Minas Gerais, Goias, Mato Grosso, Parana, Sao Paulo, Santa Catarina and adjacent localities in Paraguay (Villa Rica).

SYMBIOPSIS PUPILLA (Draudt), new combination

Figure 4; Plate I (Fig. 5 and 6)

Thecla pupilla Draudt, *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:801, pl. 158, figs. i-4, i-5. Comstock and Huntington, 1963, J. N. Y. Ent. Soc., 71:46.

Original description:

"... is above black-brown, towards the base with a slight blue-grey tint, on the hindwing with a large red anal spot being bordered at first by black, then by white; beneath brown-grey, the lines like in the preceeding (*Th. panamensis*) but finer; the submarginal lunae almost extinct, from the upper median vein to the proximal margin distinct as an entirely straight black line being removed far inward and touching dents of the postdiscal band. The red spot of the tail and the anal spot extremely large, connected by a broad red bridge, the black pupil of the spot of the tail very small, strigiform."

There are no obvious differences between the male and female of this species. Even the size differential (the males average slightly larger) is more individual than sexual. The phrase, "... above black-brown, towards the base with a slight blue-grey tint" is an excellent capsule description of the upper surfaces of both wings. Based on specimens examined during this study, *pupilla* can be further characterized as follows.

Upperside: Anal lobe spot of hindwing small, rather than large, centered with a sprinkling of orange-red; a marginal black line and an inwardly adjacent white line beginning in interspace above the short tail at M_3, tracing outer margin to anal lobe.

Male: Length of forewing, 12 mm.

Female: Length of forewing, 11 mm.

Underside: Ground color of both wings a light, silky brown-grey, submarginal lunular line of forewings, faint and indistinct; postmedian line narrow, black, distally edged in white, beginning just short of costal margin, ending at vein Cu_2. Postmedian line of hindwing brown-black, distally edged in white, beginning at costal margin, uneven, then forming a sharply angular "W" before terminating at inner margin; center of "W" mark or semi-macule dark brown; cubital spot between tails large, deep red with a small, strigiform, black pupil at distal center, red scaling of cubital spot often spilling into interspace M_3; blue spot adjacent to cubital spot also large, proximally edged with a bridge of red scales, reaching black spot of anal lobe; the submarginal line of vague, indistinct lunae; marginal line black, inwardly edged in white, tracing outer margin from vein M_2 to anal lobe, expanded slightly at each vein terminus; spot of anal lobe black.

The expanded description and illustrations herein have been taken from a series of five males and ten females collected by Mr. and Mrs. Jorge Kesselring in Joao Pessoa, Paraiba, Brazil. The dates cover the period December through June; one female was collected on 31 October. In the National Museum, Rio do Janeiro, Brazil are a male and female of *pupilla* taken at Belem do Para and another male taken at Amapa. Dr. Ebert's collection contains a series of *pupilla* taken in Paraiba. A female from the Oberthur collection in the British Museum carrying the label "Amazonas" is placed here. Major A. Bedford Russell, British Coldstream Guards, collected a single female at Apoteri, British Guiana in September 1963.

Available information (Bailey, 1947) indicates that Draudt's types have been destroyed. It appears advisable that a neotype be designated. A neotype female, BRAZIL, Joao Pessoa, Paraiba, 6 June 1954, is therefore designated from the series described above and placed in the National Museum of Natural History (Smithsonian Institution), Washington, D. C. (USNM Type No. 71451).

Seitz' terse "Guiana to Colombia and Bolivia" covers a very large area. The currently known geographical distribution for *pupilla* is rather restricted, being confined to the Guianas and the adjacent northeastern coastal area of Brazil as far south as the state of Paraiba.

SYMBIOPSIS SMALLI Nicolay, new species

Figure 5; Plate II (Fig. 1, 2, 3 and 4)

Male: Length of forewing, 13 ± 1 mm; holotype, 13 mm.

Upperside: Forewing margin broad, black-brown, reaching well into discal cell; the shining dark blue confined to lower one-third of wing along inner margin, extending

past vein Cu_2 into cell. Hindwing margin narrow, black-brown, slightly expanded at apex; remainder of wing shining dark blue; anal lobe spot black, narrowly edged above and below with pure white; a narrow, vague, white marginal line from small tail at Cu_1 to anal lobe.

Underside: Forewing ground color dark brownish grey; submarginal line vague, indistinct; postmedian line almost straight, black-brown, distally bordered with a few white scales, extending from near costal margin, terminating at Cu_2. Hindwing ground color dark brownish grey; postmedian line uneven, black, distally edged in white, cleanly broken inward at vein M_3, terminating at inner margin after tracing a broad deep "W"; submarginal line composed of vague, light grey crescent-shaped lunae; a black marginal line, edged basaly in white, beginning at vein M_1, becoming broader and more definitive at cubital red spot between tails; cubital spot orange-red, large, with a large strigiform black pupil at distal center, spilling unevenly into adjacent interspace M_3; a broad red band proximally borders the large grey-blue spot, the two colors almost of the same width; anal lobe spot black, with proximal and distal margins white, and with a connecting red line running costad to red bar of Cu_2; a rudimentary black spot at basal margin of large blue spot in Cu_2, touching the red bar.

Female: Length of forewing, 12 mm.

Upperside: Markings and ground color similar to male; the dark shining blue area less brilliant in forewing, restricted to a small discal and basal area adjacent to inner margin along vein 2A. Hindwing margins narrower, the dark blue thus more extensive in the discal and basal area.

Underside: Ground color brownish grey with a slight lustre; all linear markings similar to male, heavier, the red cubital spot expanded into interspace M_3.

Holotype male: PANAMA, Los Rios, Canal Zone, 10 December 1967. Allotype female: same locality, 17 December 1964. Paratypes, 41 male (m) and 7 female (f), as follows. From Gordon B. Small's collection: Los Rios, C.Z., 1 m, 31 Oct., 3 m, 11 Nov., 6 m, 13 Nov., 1 m, 14 Nov. 1965; 1 m, 1 Dec., 1 m, 7 Dec., 1 m, 10 Dec., 1 m, 12 Dec., 1 m, 13 Dec., 1 m, 19 Dec., 1964; 3 m, 20 Dec. 1967; 1 m, 12 Feb., 1 m, 23 March 1968; Ft. Sherman, C.Z., 1 m, 21 May 1966; Cerro Campana, Panama Province, 1 m, 10 Jan. 1968; 1 f, 29 May 1964; Turrialba, Cartago Prov., Costa Rica, 1 f, 14 July 1965. From the Nicolay collection: Los Rios, C. Z., 1 m, 11 Dec., 3 m, 13 Dec., 5 m, 14 Dec., 2 m, 15 Dec. 1967; 1 m, 4 Dec., 1 m, 19 Dec., 1 m, 24 Dec., 1964; 2 m, 3 f, 6 Jan. 1969; Colon (Santa Rita) Rep. of Panama, 1 m, 5 Jan., 1 f, 4 Jan., 1 f, 10 Jan. 1969.

The holotype and allotype will be deposited in the Nation-

al Museum of Natural History (Smithsonian Institution), Washington, D. C. (USNM Type No. 71452). Paratypes will be deposited in the American Museum of Natural History, New York, the Carnegie Museum, Pittsburgh, and the British Museum (Natural History), London.

Symbiopsis smalli closely resembles *S. tanais* on the upper surface. The basic blue and dark marginal colors are alike in both; the size and shape of the adults of both sexes are similar. However, the maculation of the under surface of the wings is strikingly different. Here, *smalli* closely resembles *pupilla* in the clarity and color of the linear markings.

Thus far, *smalli* has been found in the Republic of Panama, Costa Rica and Colombia, with a known altitude ranging from sea level to 2000 feet. Its primary flight period appears to be the winter months of November through February although it has been taken in almost all seasons. Examined, but not included in the type series, was a male collected in Jaque, Darien Province, Panama in April and a male in the British Museum, taken in Cundinimarca, Colombia.

It is a distinct pleasure to name this beautiful insect after my good friend and collecting associate, Gordon B. Small, Jr. who collected most of the specimens.

SYMBIOPSIS PENTAS Nicolay, new species

Figure 6; Plate III (Fig. 1, 2, 3 and 4)

Male: Length of forewing, 12 mm ± 1 mm; holotype, 12 mm.

Upperside: Forewing dark brown with no blue scaling. Hindwing opalescent violet-blue in the disc with wide (2-3 mm) dark brown margins, widest at apex; an inconspicuous white submarginal line, beginning just above the small tail at M_3 tracing wing margin to anal lobe; latter small, black with intermixed bronze colored scales, proximally and distally white fringed.

Underside: Forewing ground color light brown-grey; submarginal lunular line faint, dark brown, broken at each vein; postmedian line dark brown, faintly and distally outlined with light scaling, ending abruptly at vein Cu_2. Hindwing ground color the same brown-grey; submarginal line faint, dark brown crescents, separated at each vein, distally and proximally edged in faint light scaling; postmedian line dark brown, distally edged in white, beginning at costal margin, rather uneven, becoming black, forming a broad angular "W" beginning at Cu_1 and ending at inner margin; cubital spot at Cu_1 small, orange-red, the black pupil distally centered , prominent; blue spot of Cu_2 proximally bordered by a narrow bridge of red scaling beginning at black anal lobe spot, not reaching vein Cu_2; semi-macule dark brown; a mar-

ginal black line, expanded at each vein and inwardly edged in white, beginning at vein M_2 and ending at anal lobe.

Female: Length of forewing, 11 mm ± 1 mm; allotype, 11 mm.

Upperside: Forewing and hindwing dark brown with no trace of blue; anal lobe spot black; marginal white line from vein M_3 very faint.

Underside: Same as in male.

Holotype male: BOLIVIA, Cuatro Ojos, Nov. 1913. Allotype female: Las Juntas, Bolivia, Dec. 1913. Paratypes, 3 male, 5 female, as follows. In the Carnegie Museum: 1 m, Las Juntas, Bolivia, Nov. 1913, 1 m, Cuatro Ojos, Bolivia (no date); 3 f, Las Juntas, Bolivia, Dec. 1913, 1 f, Cuatro Ojos, Bolivia, Nov. 1913. In the Smithsonian Institution: 1 m and 1 f, "Peru", no date. W.D. Field in his discussion of *Calystryma malta* Schaus, refers to a fourth specimen of the original Schaus series, a female, as not belonging to *Calystryma*. It is this female that is here designated a paratype.

The holotype and allotype are deposited in the Carnegie Museum, Pittsburgh, Pennsylvania.

The complete lack of blue on the upperside of the forewings in the male makes this species relatively easy to distinguish from other members of the genus. However, the female is almost indistinguishable from the female of *pennatus* except by examination of the genitalia. Both are dark brown on the upper wing surfaces and very similar beneath. The most consistent difference between this species and *pennatus*, is in the black pupil of the cubital spot; in *pentas* this spot is round and prominent, in *pennatus* it is strigiform, ill-defined and almost obsolete in some specimens. In the genitalia, particularly that of the male, there are consistent and easily recognized differences as noted in the appropriate figures.

I have seen no specimens of *pentas* other than those in the type series. The known range of this species is Bolivia and Peru.

SYMBIOPSIS PANAMENSIS (Draudt), new combination

Figure 7; Plate II (Fig. 5 and 6)

Thecla panamensis Draudt, *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:801, pl. 158, figs i-1, i-2. Comstock and Huntington, 1962, J. N. Y. Ent. Soc., 70:101.

Original description:

"... is the most similar to *pisidula*; but it is above of a light greenish steel-blue, with a strong lustre, black margins of the same extent as in pisidula; the female is of a duller grey-blue. Beneath more purely grey, with a slight lustre, the linear marking stronger, particularly the white bordering more pronounced, the submarginal lunae more distinct, the red spot of the tail very large, so is the light blue spot beside it."

The sexes are similar in appearance, and the description may be elaborated as follows.

Upperside: Greenish steel-blue lustre accentuated by the narrow black margins, more so than in any other species except *morpho*; margin rather sharply defined in forewing of male, rather vaguely defined and slightly broader in female; black marginal color almost filling primary wing cell in female. Dark margin of hindwing consisting of thin line, slightly expanded at apex, the same greenish steel-blue filling entire hindwing in both sexes; anal lobe spot black set within a sprinkling of white scales.

Underside: Submarginal line of forewing of the same lustrous grey as basic ground color of both wings but darker and distinct, running from subapical area to tornus; postmedian line very dark grey, narrow, distally edged in white, following the same curve as the submarginal but ends abruptly at vein Cu_2. Postmedian of hindwing a conspicuously black line, distally edged in white, slightly broken, beginning at costal margin, then forming a broad "W" prior to termination at inner margin; semi-macule black; submarginal lunae proximally shaded in light grey; marginal line from M_1 to anal lobe;black, inwardly edged in pure white; cubital spot between tails orange-red, large, with a strigiform black pupil at distal center; a very narrow red bar proximally bridging a large light blue spot adjacent in interspace Cu_2, almost reaching the small black spot of anal lobe; fringes white-tipped between the short tail at Cu_1 and anal lobe.

The underside pattern of *panamensis* closely resembles *strenua*. All markings are similar but in *panamensis* are more definitive, the spots larger and the ground color greyish with a slight lustre. Males and females are alike, with the ground color of the females generally lighter, almost brownish rather than grey.

The above observations were made from specimens which Gordon Small and I collected at Potrerillos, Chiriqui Province, in western Panama; dates of capture were in the months of December, January, February and July. In addition, Gordon Small has taken a single specimen at Villa Neily in the adjacent province of Puntarenas, Costa Rica in July.

Available information (Bailey, 1947) indicates that Draudt's types have been destroyed. It appears adviseable

that a neotype be designated. A neotype, male, PANAMA, Potrerillos, Chiriqui Province, 11 Feb. 1966, is therefore designated from the series described above and placed in the National Museum of Natural History (Smithsonian Institution), Washington, D. C. (USNM Type No. 71453).

SYMBIOPSIS MORPHO Nicolay, new species

Figure 8, Plate III (Fig. 5 and 6)

Male: Unknown.

Female: Length of forewing, 15 mm.

Upperside: Forewing costal and outer margins black, narrow with a wide expanse of brilliant greenish steel-blue color filling cell, disc, basal and most of inner marginal area. Hindwing the same shining morpho-like blue; outer margin a thin, black line expanded at apex; abdominal fold dark grey; anal lobe spot large, black, narrowly fringed in white.

Underside: Forewing ground color silky light brown; submarginal line darker brown, faint but distinct; postmedian line narrow, blackish-brown, distally edged in white, ends at vein Cu_2. Hindwing ground color light brown; postmedian line sharply black, distally edged in pure white, displaced outward at interspace Sc + R_1, broken inward at vein M_3, terminating at inner margin after tracing a broad "W"; submarginal line dark brown, consisting of crescent-shaped lunae, distally and proximally edged in light scaling; cubital spot in Cu_1 very large, deep red, proximally spilling into adjacent space, reaching vein M_3; the black pupil centered at distal edge large, strigiform; blue spot of Cu_2 capped by a rudimentary black spot, completely bridged proximally by a red bar extending from cubital spot to the large black spot of anal lobe; latter proximally and distally framed in white.

Holotype female: EQUADOR, Paramba, 3500 ft., March 1897, dry season (Rosenberg); in the British Museum (Natural History), London.

This is the largest and most lavishly colored *Symbiopsis*. The upper surface is of the same shining steel-blue lustre of *panamensis*, the dark margins similarly narrow. Beneath, *morpho* is a rich brown color, rather than greyish. It is more heavily marked than any other species of this genus. I suspect that the male, when found, will be larger than the female, with narrower dark margins on both wings and a larger expanse of brilliant blue color on the upper surfaces.

In response to my request for specific information on the locality Paramba, Mr. Tite of the British Museum very kindly provided the following quote from a paper by Dr. Hartert dealing with the birds collected by W.F.H. Rosenberg:

"Paramba is a farm on the western bank of the river Mira. Its elevation is 3500 feet, and it is still in the forest region, but the open country commences two or three miles higher up the Mira...The city of Ibarra two days ride from Paramba, and about the same distance from Quito..."

SYMBIOPSIS PENNATUS (Druce) new combination

Figure 9; Plate IV (Fig. 1 and 2)

Thecla pennatus Druce, 1907, Proc. Zool. Soc. London, :617-18. Draudt *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:800. Comstock and Huntington, 1962, J. N. Y. Ent. Soc., 70:106.

Original description:

"Male. Allied to *T. anthora* Hew. Upper side uniform dark brown, with inner margin of fore wing narrowly, and discal and basal areas of hind wing shining opalescent indigo-blue. Under side; ground colour duller; the linear bands narrower, placed further in from the margin and in the hind wing not inwardly bordered with red. The upper red marginal spot with the black pupil of *T. anthora* is absent, and the large red spot contained in the angle of the ultramedian band is replaced by a black, smaller spot.

Female. Upper side uniform dull brown; underside as in male.

Expanse, 1 1/5, 1 1/10 inch.

Hab. Amazonas: Tapajos, Ega, Para (Bates).

Types, Mus. Godman."

The brevity and accuracy of Druce's original description needs little elaboration. The anal lobe spot on the upper hind wing is black, centered with sparse orange-red; the marginal black line from vein M_3 to the anal lobe is inwardly edged in white.

On the underside the cubital spot of the hindwing is relatively small, orange-red and pupiled by a vague, ill-formed almost obsolete black spot. The red bar, beginning at the black anal lobe spot is narrow and, although arched over the proximal edge of the blue spot of Cu_2, is incomplete and does not reach vein Cu_2.

The male genitalia of *pennatus* has a ventral keel on the aedeagus. It is not obvious and is confined to the posterior end. The genitalia of *tanais* and *nippia* are similarly equipped.

Male: Length of forewing, 12-13 mm.

Female: Length of forewing, 11-12 mm.

As stated by Druce, *pennatus* is certainly a distinct species, but it is not related closely to *T. anthora* Hew. In pattern of lines and color it is most similar to *pentas*, the females being almost identical. However, the genitalia reveal a close relationship to *tanais* and *nippia*, both of which possess macular patterns beneath which are distinctly different from *pennatus*. The most consistent difference between *pennatus* and other species of similar appearance is in the black pupil of the cubital spot. In *pennatus* it is small, ill-formed, almost obsolete, while in *pentas* and others, it is prominent. The narrow blue scaling along vein 2A in the forewing will readily separate the males from *pentas*, its closest mimic.

The geographical range of this species is large, taking in much of the vast expanse of the Amazon basin. The present data adds Colombia, Peru and Bolivia to the political regions given by Druce. Recorded altitudes are from near sea level to 450 meters.

In addition to examination of the type series in the British Museum, I have studied a male collected in Ega (Brazil), a series of four males and three females from the Rio Surutu and Portachuelo in eastern Bolivia, and a male from Manacapuru, Amazon River, in the Carnegie Museum, and a male and two females which I collected on the Rio Bodoquero, Caqueta, Colombia, in January.

SYMBIOPSIS TANAIS (Godman & Salvin), new combination

Figure 10; Plate IV (Fig. 3 and 4)

Thecla tanais Godman and Salvin, 1887, Biologia Centrali-Americana, Lepid.-Rhop., 2:62; 3:pl. 55, figs 27, 28. Draudt *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:800, pl. 158, fig. 1-5. Comstock and Huntington, 1964 J. N. Y. Ent. Soc., 72:121.

This is one of the most distinctive and easily recognized species in the genus. The original description was given in Latin, and the species may be characterized as follows.

Male: Length of forewing, 13-14 mm.

Female: Length of forewing, 11-13 mm.

Upperside: Similar to *smalli*, differing as follows: center of the anal lobe spot in *tanais* orange-red, in *smalli* black; blue scaling of forewing more restricted to inner margin (never reaching vein Cu_2) in *tanais*, extending past vein Cu_2 into the cell in *smalli*.

Underside: Ground color light grey-brown. The submarginal and postmedian lines of forewing both faintly marked; dark brown scaling filling semi-macule and distal to postmedian line in Cu_1; the large powder-blue spot between tails in interspace Cu_1 and an adjacent spot of the same (to slightly larger) size and color in interspace Cu_2 provide the most distinctive identification feature of this species; anal lobe spot black, with a narrow red bar (the only red color on the underside) between it and the blue spot adjacent; an obvious black marginal line, inwardly edged in white and expanded at each vein terminus, beginning at vein M_2, ending at anal lobe.

Male and female genitalia following basic pattern for genus except aedeagus with a ventral keel.

Many of the specimens from which these observations were made were collected in the Republic of Panama and the Canal Zone by Gordon Small and I. Altitudes from which the Panama specimens were taken range from sea level to 2500 feet. Specimens in Gordon Small's collection were taken as follows: Cerro Campana, Panam Prov., December; Cocoli, C.Z., November; Madden Dam, C.Z., April; Summit, C.Z., April; a rather worn female, from Victoria, Caldas, Colombia, in August. In the Nicolay collection: Cerro Campana, December, January and February; Summit in April; Madden Forest in May and Pina, C.Z. in May.

There are four males in the collection of the Smithsonian Institution, all from various localities in Costa Rica. One altitude notation reads 2500-3500 feet. The dates are Nov. '06, Feb. and March. In the American Museum of Natural History are three males and six females all collected by H.H. and F.M. Brown at Turrialba, Costa Rica on 24 and 27 June. All specimens noted above agree with the types located in the British Museum (Natural History), London.

Godman and Salvin restricted the range of *tanais* to the state of Panama; Seitz added the Rio Dagua in Colombia. *Symbiopsis tanais* has thus far been taken in Costa Rica, Panama and Colombia.

SYMBIOPSIS NIPPIA (Dyar), new combination

Figure 11; Plate IV (Fig. 5 and 6)

Thecla nippia Dyar, 1918, Proc. U. S. Natl. Mus., 54:337. Draudt *in*: Seitz, 1920, Gross-Schmett. der Erde, 5:824. Hoffmann, 1940, An. Inst. Biol., 11:714. Comstock and Huntington, 1961, J. N. Y. Ent. Soc., 69:196.

Original description:

"Fore wing blackish, shaded with light blue on the basal third below cell and in cell to its end. Hind wing blue

to vein 6; fringe white; a black terminal line; tail at vein 2 long, white margined and tipped; tail on vein 3 short, white; fore wing with faint whiter outer line, dislocated at the veins. Hind wing with the outer line slender, blackish, edged without by white, forming a shallow W from vein 3 to margin; a faint submarginal line; a red spot in the interspace 2-3 with outer black center; a black and red speck at tornus. Expanse, 25 mm.

Type. -- Female, Cat. No. 21201, U.S.N.M.: Sierra de Guerrero, Mexico, January, 1911 (R. Muller)."

The male, which Dyar did not describe, is similar to the female on the upper surface and identical on the undersurface of the wings. On the upperside the blue of the forewing is not as extensive as in the female, being confined to the discal and basal area of the inner margin; the hindwing has a wider dark margin (3mm at the apex) and the blue of the discal and basal area is darker and more intense. The anal lobe spot is red and a marginal black line with an inner white line begins at vein M_3 and ends at the anal lobe spot.

It is worthy of note that the two species with the lightest ground color on the underside of the wings occur at the southern and northern extremes of the known geographical distribution of the genus, *lenitas* from southern Brazil and Paraguay and *nippia* from the state of Jalisco, Mexico. Both are easily recognized by the greyish-white ground color upon which the linear markings are rather faintly contrasted and by the "W" mark of the postmedian line shallow rather than angular. Dyar's "black and red speck at the tornus" refers th the orange-red bar that lies between the small black spot of the anal lobe and the blue spot of Cu_2. It is arched partially over the proximal margin of the latter. The cubital spot is small, orange-red with a yellowish proximal margin and centered at the distal edge with a prominent black pupil.

As in *tanais* and *pennatus*, the male aedeagus of *nippia* has a ventral keel. Otner small differences in the genitalia can be noted in the appropriate figures.

In the American Museum of Natural History are four males and five females from the C.C. Hoffmann collection taken in April at Colima, Colima, Mexico. In the Carnegie Museum is a male taken by R.G. Wind in May at Comala, Colima, Mexico. The recorded range of *nippia* is the west coastal area of Mexico from the state of Jalisco south to Guerrero.

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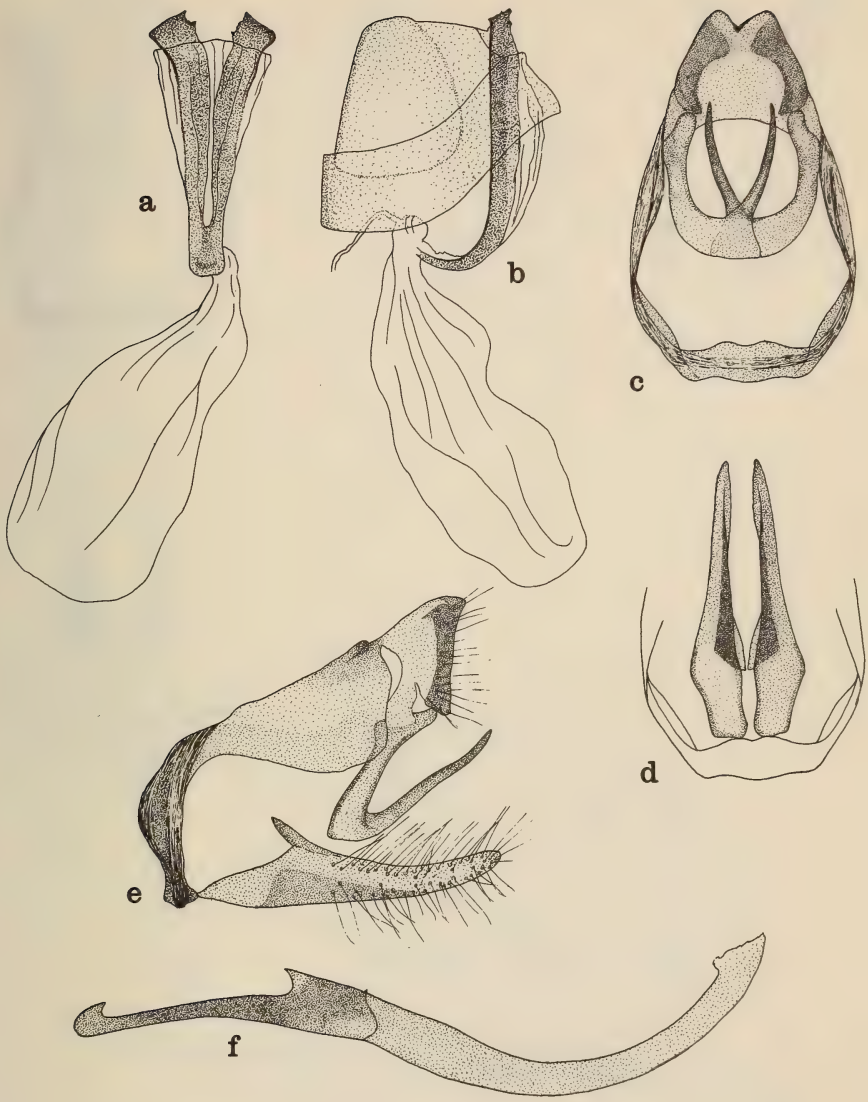


Figure 2. *Symbiopsis strenua* (Hewitson). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

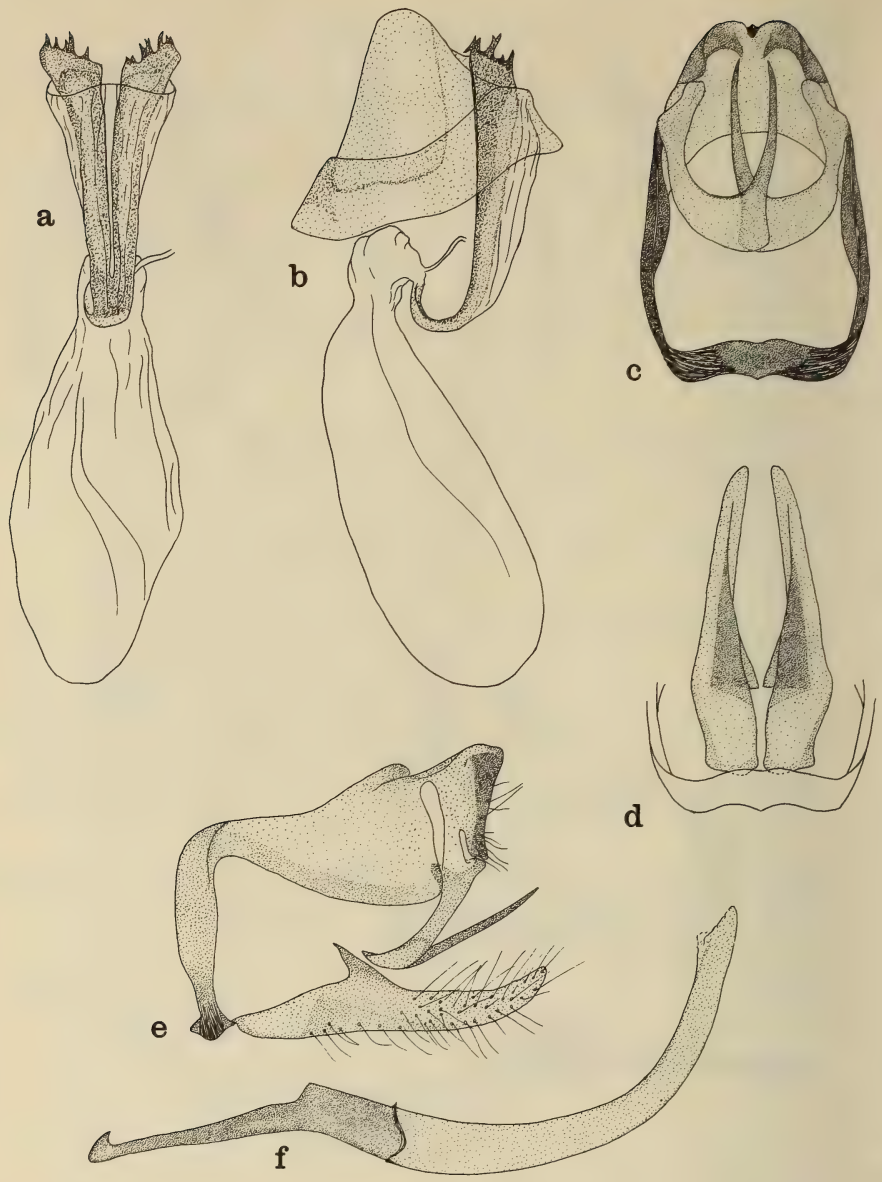


Figure 3. *Symbiopsis lenitas* (Druce). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 7th and 8th tergites; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

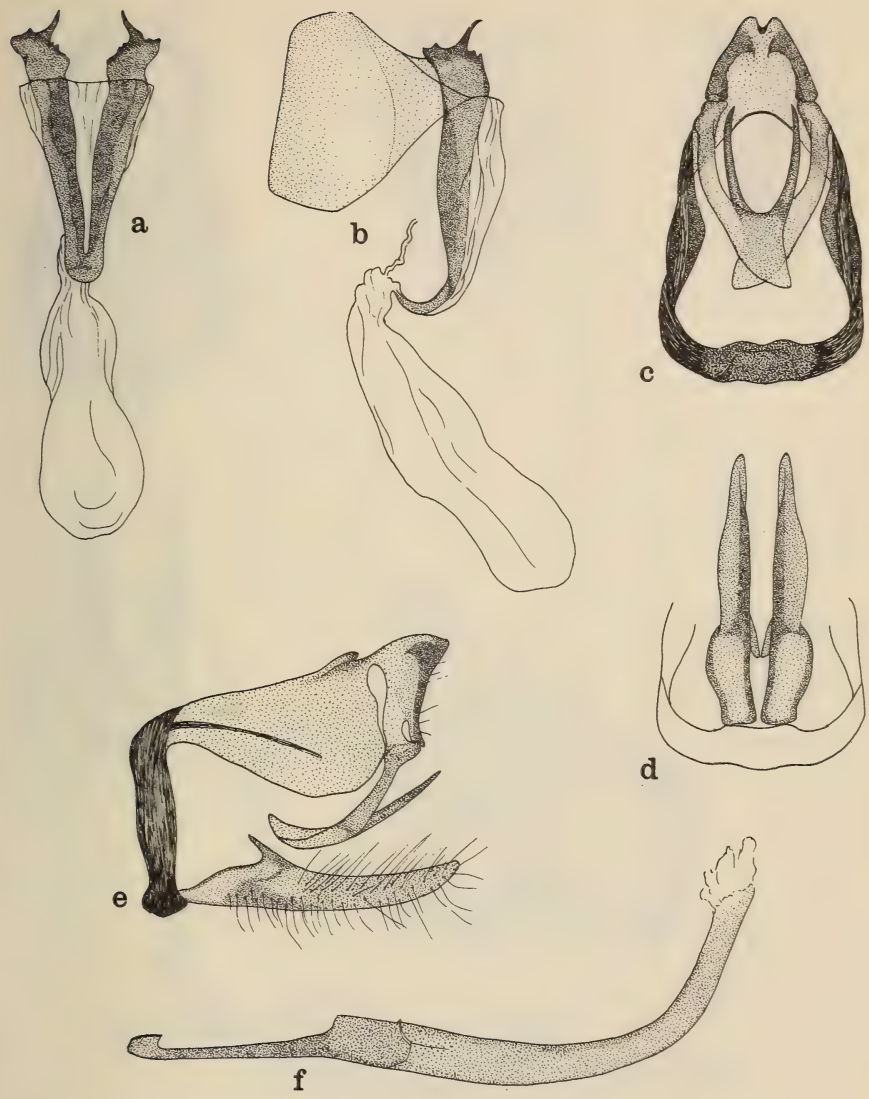


Figure 4. *Symbiopsis pupilla* (Draudt). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

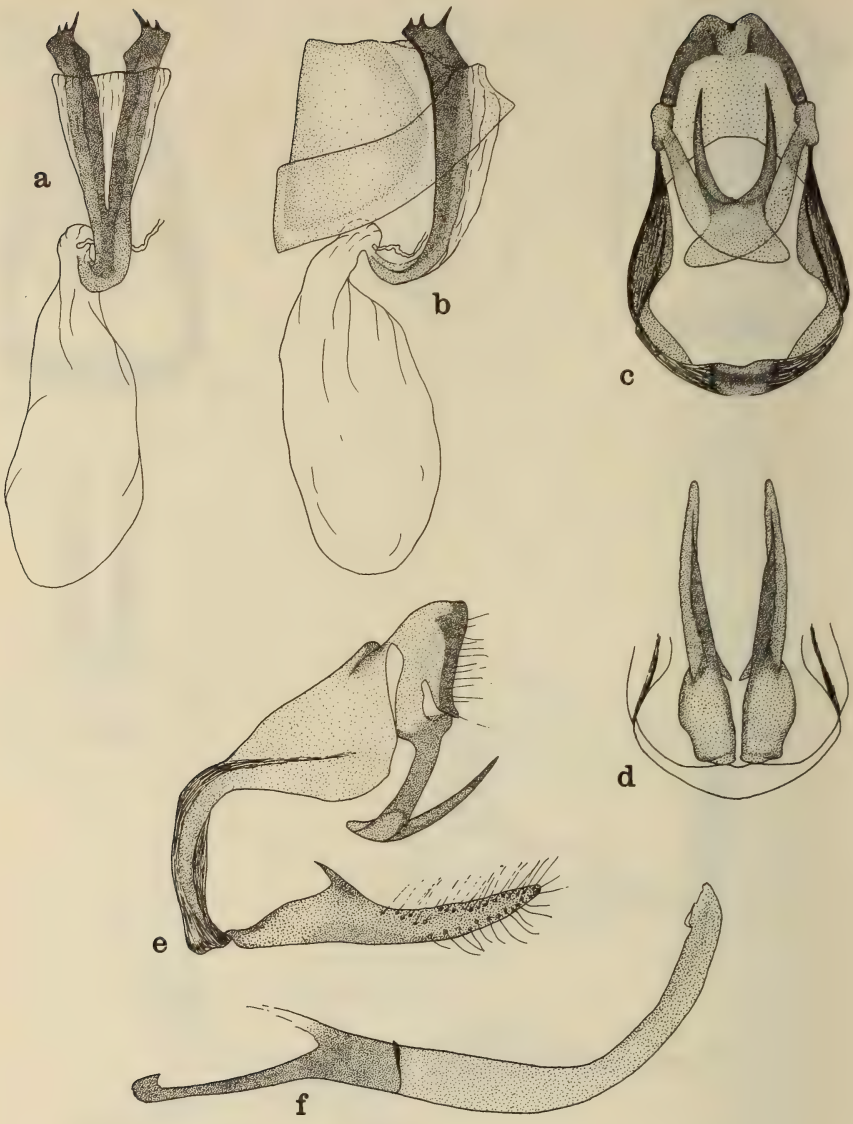


Figure 5. *Symbiopsis smalli* Nicolay. a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 7th and 8th tergites; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

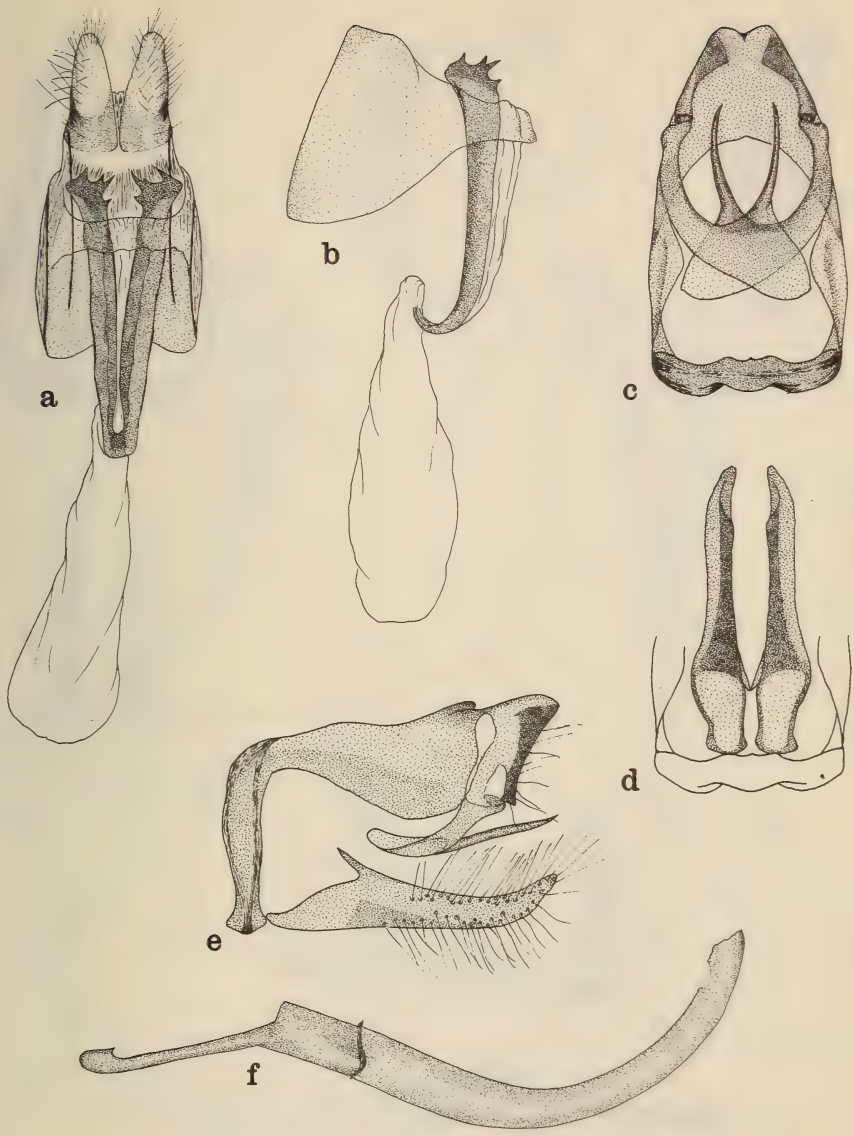


Figure 6. *Symbiopsis pentas* Nicolay. a, ventral view of female genitalia; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

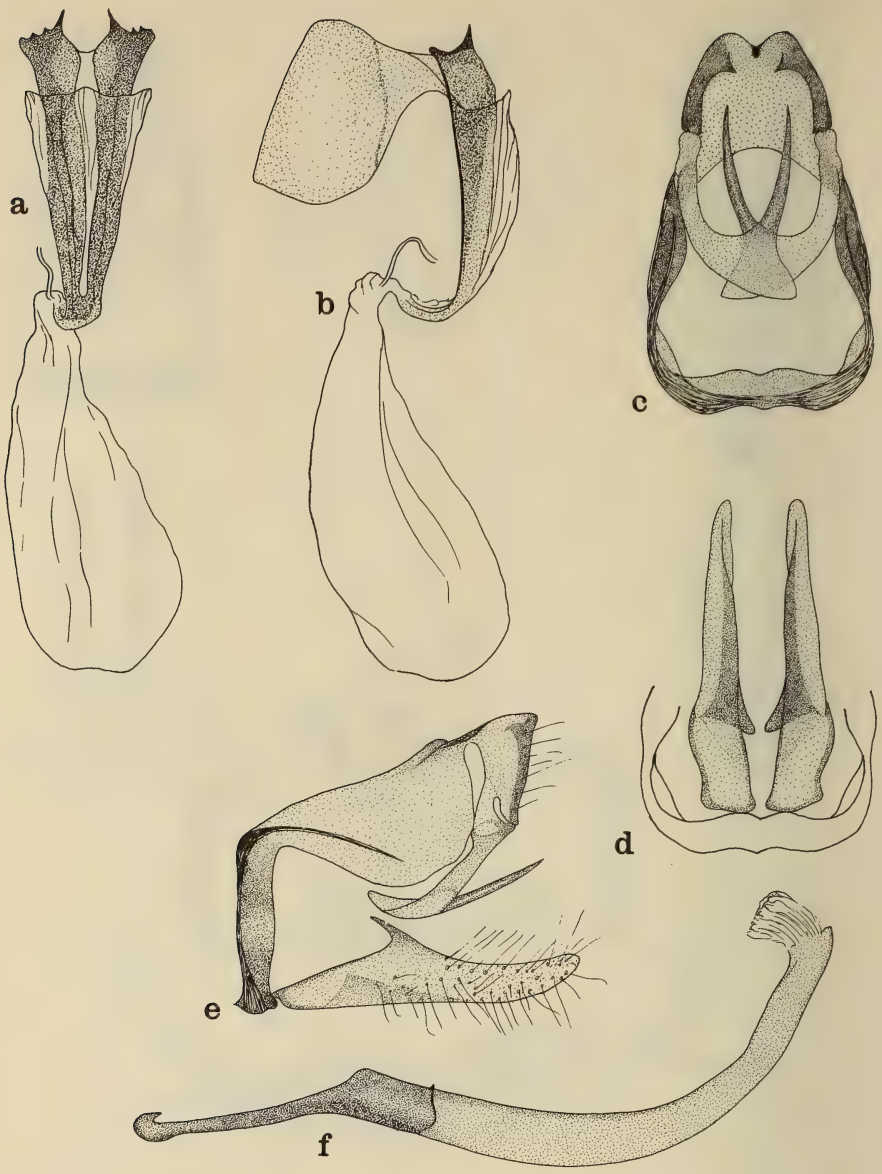


Figure 7. *Symbiopsis panamensis* (Draudt). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.

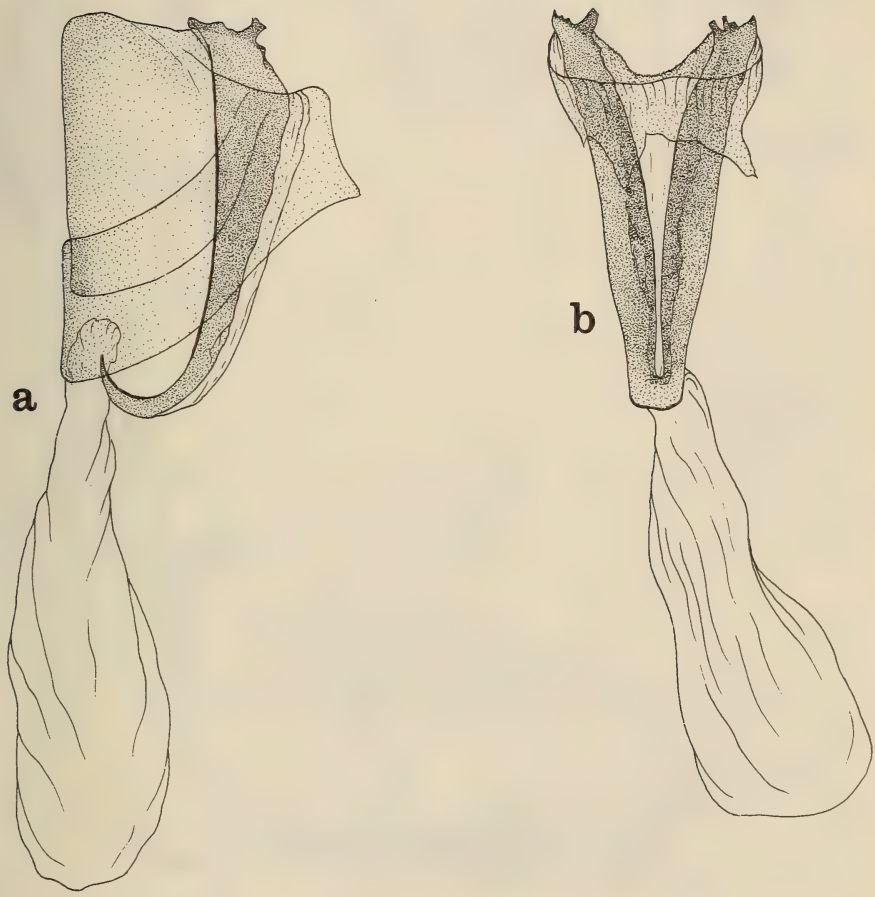


Figure 8. *Symbiopsis morpho* Nicolay. a, lateral view of female genitalia without ovipositor, with 7th and 8th tergites; b, ventral view of female genitalia without ovipositor, with part of 8th tergite.

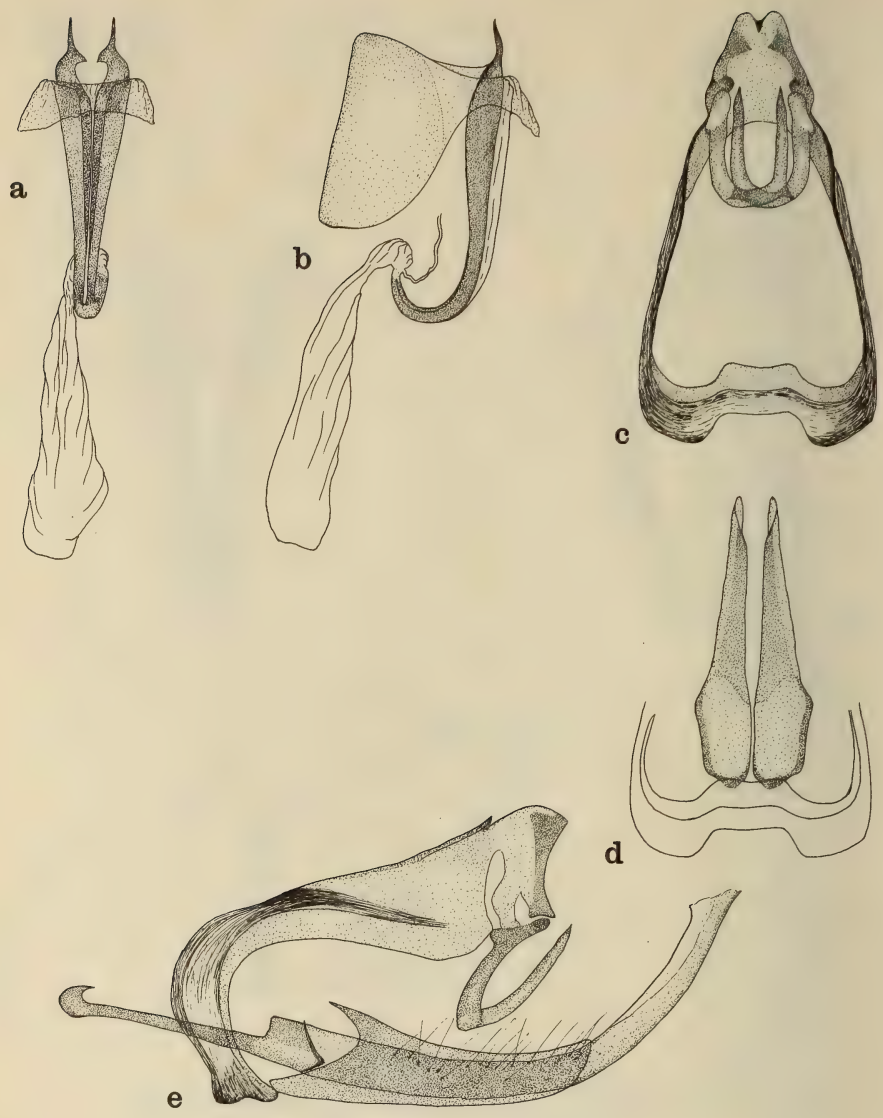


Figure 9. *Symbiopsis pennatus* (Druce). a, ventral view of female genitalia with ovipositor removied, with part of 8th tergite; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus *in situ*.

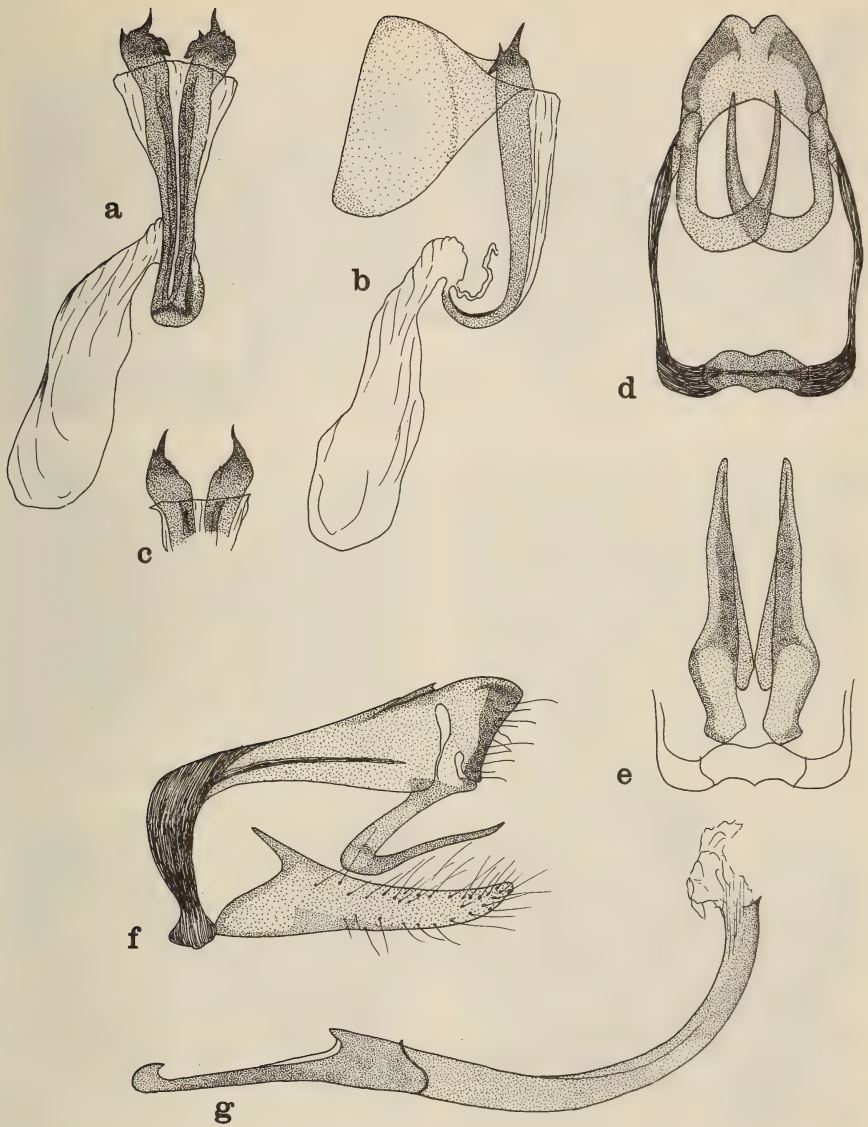


Figure 10. *Symbiopsis tanais* (G & S). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, variation in spines of ostium; d, ventral view of male genitalia with valvae and aedeagus removed; e, ventral view of valvae; f, lateral view of male genitalia with aedeagus removed; g, lateral view of aedeagus.

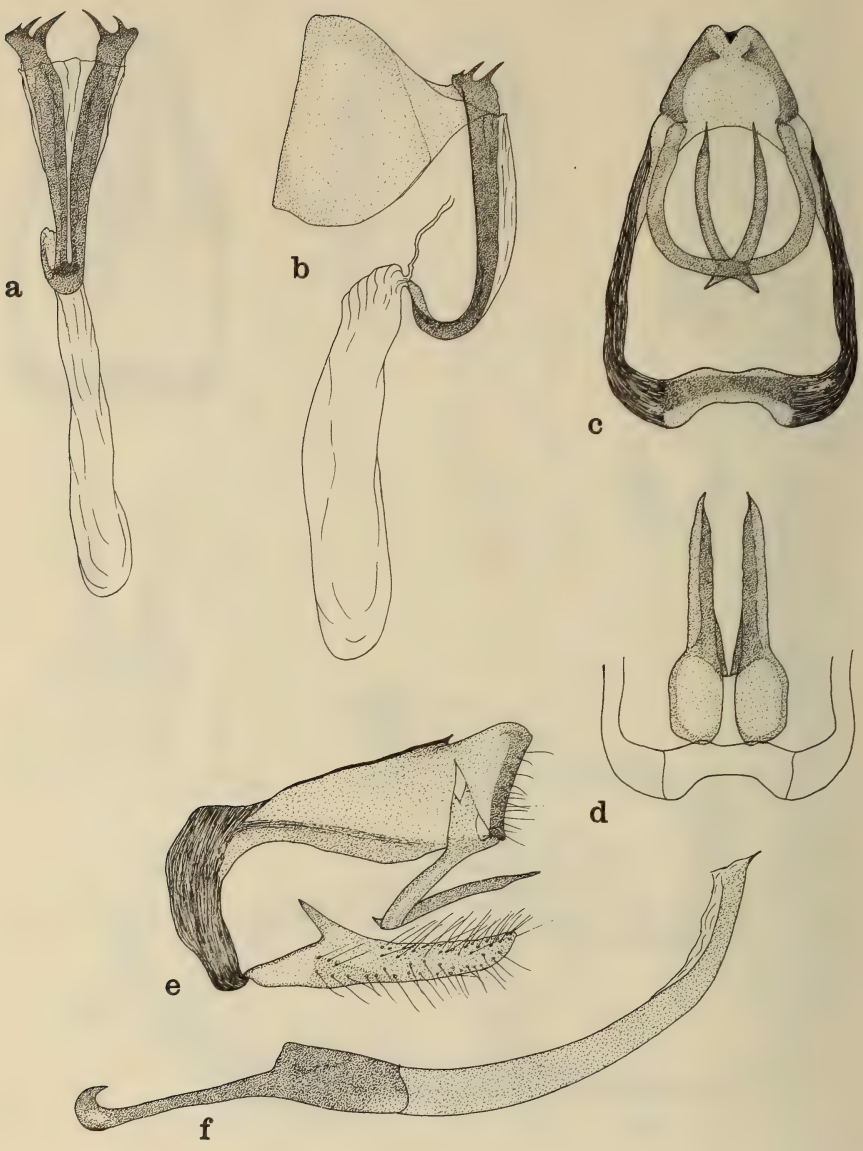
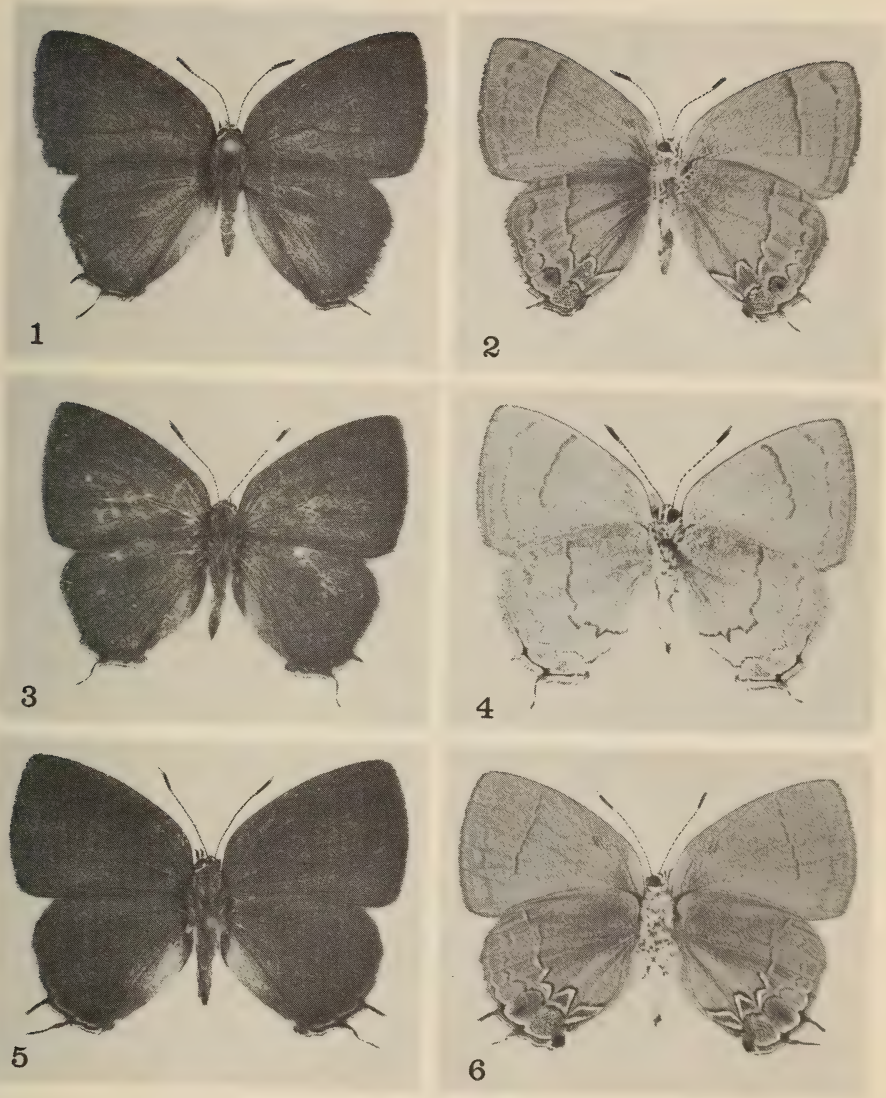


Figure 11. *Symbiopsis nippia* (Dyar). a, ventral view of female genitalia with ovipositor and tergites removed; b, lateral view of female genitalia without ovipositor, with 8th tergite; c, ventral view of male genitalia with valvae and aedeagus removed; d, ventral view of valvae; e, lateral view of male genitalia with aedeagus removed; f, lateral view of aedeagus.



Figures 1, 2, *Symbiosis strenua* (Hewitson) male, Nova Teutonia, Santa Catarina, Brazil; 3, 4, *S. lenitas* (Druce) male, Nova Teutonia, Santa Catarnia, Brazil; 5, 6, *S. pupilla* (Draudt) (neotype) male, Joao Pessoa, Paraiba, Brazil.



Figures 1, 2, *Symbiopsis smalli* Nicolay (holotype) male, Los Rios, Canal Zone, Panama; 3, 4, *S. smalli* (allotype) female, Los Rios, Canal Zone, Panama; 5, 6, *S. panamensis* (Draudt) (neotype) male, Potrerillos, Chiriqui Prov., Panama.





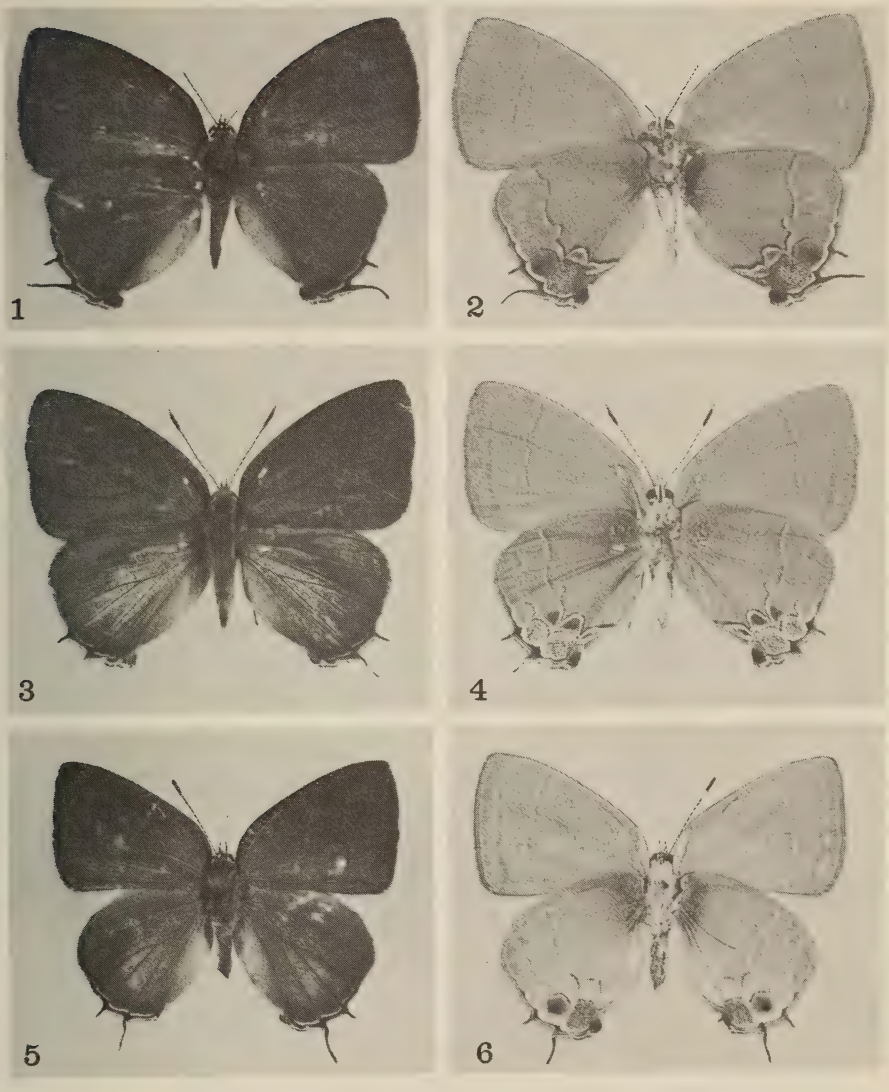








Figures 1, 2, *Symbiopsis pentas* Nicolay (holotype) male, Cuatro Ojos, Bolivia; 3, 4, *S. pentas* (allotype) female, Las Juntas, Bolivia; 5, 6, *S. morpho* Nicolay (holotype) female, Paramba, Equador.



Figures 1, 2, *Symbiopsis pennatus* (Druce) male, Ega, "Amazonas", Brazil; 3, 4, *S. tanais* (G. & S.) male, Cerro Campana, Panama; 5, 6, *S. nippia* (Dyar) male, Comala, Colima Mexico.

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This issue edited by J. A. Powell.

Supplements to Volume 23 (mailed May 6, 1970):

1. A review of the Megathymidae; by H. A. Freeman; 59 pp.

2. Records, new species, and a new genus of Hesperiidae from Mexico; by H. A. Freeman; 62 pp.

3. On the frequency of butterflies in eastern Brazil, with a list of the butterfly fauna of Pocos de Caldas, Minas Gerais; by Hans Ebert; 48 pp.

Volume 25

JOURNAL

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VOLUME 25

SUPPLEMENT 2

A BIOSYSTEMATIC STUDY OF TWO SPECIES OF CALLOPHRYS (CALLOPHRYS) IN CALIFORNIA (Lycaenidae)

by Glenn Alan Gorelick

10 May 1971

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A BIOSYSTEMATIC STUDY OF TWO SPECIES OF CALLOPHRYS (CALLOPHRYS) IN CALIFORNIA (LYCAENIDAE)

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INTRODUCTION

The genus *Callophrys* Billberg is represented in North America by six subgenera separable on the basis of male genitalia (Clench, 1961). These subgenera are *Xamia* (one species), *Sandia* (one species), *Incisalia* (eight species), *Mitoura* (seven species), *Cyanophrys* (one species) and the nominal subgenus *Callophrys* (six species).[1] The six species included in the nominal subgenus are characterized by green on the undersides of the wings, with or without presence of white maculations.

Callophrys (*C.*) *affinis* (Edwards) has a light green color usually without any maculations. This species ranges from northern Utah and Wyoming to Washington and British Columbia, and according to Clench the life history is still unknown. Two subspecies *C. a. affinis* (Edw.) and *C. a. washingtonia* Clench currently are recognized, separable on the basis of scale color dorsally and ventrally (Tilden, 1963).

A related species, *C. sheridani* (Carpenter), is characterized by a solid line of white on the ventral surface of the hindwings. There are three subspecies, *C. s. sheridani* (Carpenter), *C. s. neoperplexa* (Barnes & Benjamin), and *C. s. newcomeri* Clench, separable by the pattern and degree of development of the macular band (Tilden, 1963). The latter two are confined mostly to Washington and Oregon away from the immediate coast, whereas the nominal subspecies occurs in the Rocky Mountain states.

A third species, *C. apama* (Edw.) has two subspecies, *C. a. apama* (Edw.) and *C. a. homoperplexa* Barnes & Benjamin, the latter characterized by the absence of a macular band. The nominal subspecies is characterized by the maculations on the undersides of the hindwings tinged with black rather than the dominant white seen in other species in the subgenus.

Callophrys comstocki Henne, a recently described species, occurs in semi-arid to arid habitats from northern Inyo County in California south to the Providence Mountains of San Bernardino County. *C. comstocki* appears to be closely related to *C. apama*, but lacks the tricolored fulvous band found on the undersides of *C. apama* (Henne, 1940).

The present study concerns two species found in California, *C. dumetorum* (Boisduval) and *C. viridis* (Edwards). The former was previously considered to include two subspecies, *C. d. dumetorum* (Bdv.) and *C. d. perplexa* Barnes &

1 A recently described population from the higher elevations of the Sierra Nevada has been named *C. lemberti* by Tilden (1963), but not enough evidence concerning life history and distribution is known to confirm its specific status and relationships.

Benjamin, occurring from British Columbia to Baja California Norte, with *perplexa* said to be confined to San Diego and Los Angeles counties, and adjacent portions of Baja California. The ventral sides of the hindwings of this species are a light green with a variable number of white maculations.

A third entity was recently described from the Pacific Northwest as *C. d. oregonensis*, based on restriction of the gray scales to the Cu_2 vein on the undersides of the forewings as well as on comparative notes on this entity's biology (Gorelick, 1970).

The last species, *C. viridis* (Edw.) which also has a variable number of white maculations, is known only from San Mateo County to Mendocino County, California, along the immediate coast. The deep yellow to blue-green tinge separates *C. viridis* superficially from *C. sheridani* and *C. dumetorum*.

Barnes & Benjamin (1923), Clench (1944) and Tilden (1963) in characterizing differences between species in the subgenus *Callophrys*, included morphological features such as scale color (wing fringes, forewing costa below, shade of green below, labial palpi, facial hairs, and dorsal ground color) and shape or angle of forewing and hindwing margins. After examining a large series of specimens of the two so-called species, *Callophrys dumetorum* (Bdv.) and *Callophrys viridis* (Edw.), the present author found no evidence which seemed conclusive or sufficient to warrant separation of the two as species. These characters vary considerably even within a single population.

Populations of the two were found to be allopatric, indicating that interbreeding probably does not occur. In the absence of evidence of interbreeding, biological characteristics such as differences in female ovipositional substrate and differences in courtship and mating are characteristics which were examined in an attempt to confirm or refute a specific level of differentiation between the two. Comparisons of larval morphology, host specificity, and development time were also used to help determine whether the two are to be considered subspecies or species.

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HISTORICAL REVIEW

Linnaeus, in 1758, proposed the genus *Papilio* which included a diversity of butterflies. A single hairstreak characterized by the complete green undersides of the wings was named *Papilio rubi*. The name *Callophrys* was originally propounded by Billberg (1820) to include three groups of lycaenids based on possession of three tails, two tails and one tail. In the group characterized by one tail only *P. rubi* was recorded. *P. rubi* was selected as the type of the genus *Callophrys* by Scudder in 1875 although the more encompassing generic name *Thecla* remained in general usage until 1914.

Boisduval (1852) described *Thecla dumetorum* which he believed to be a local race of the European species.

W. H. Edwards (1862) described *Thecla viridis*, characterized by the uniform deep green wing undersides and by white antennae.

Barnes & Benjamin (1923), after examining a small series of *Callophrys dumetorum* from the San Diego area, named the southern California race *perplexa* on the basis of complete or almost complete absence of white maculations on the undersides. They also believed *Callophrys viridis* to be conspecific with the typical northern California race of *Callophrys dumetorum*, rendering *C. viridis* a synonym of *C. dumetorum*.

Comstock (1927: plate 50) pictured a male and female of *C. viridis* from San Francisco which he labeled "*C. dumetorum*", but *C. dumetorum*, in reality, does not occur in San Francisco.

Clench (1944) revised the genus *Callophrys* and cited *C. viridis* as a species. San Francisco was named as the type locality and a neotype was designated.

Ziegler (1960), in his revision of the Lycaenidae based on male and female genitalia, combined *Mitoura* Scudder, *Sandia* Clench and Ehrlich, and *Callophrys* Billberg under the latter, making each a subgenus.

Tilden (1963) discussed many diagnostic characters useful in separating the members of the subgenus *Callophrys*, emphasizing scale patterns and wing shapes.

Gorelick (1970) described *Callophrys dumetorum oregonensis* from the Pacific Northwest based on scale patterns and biological data.

METHODS AND MATERIALS

The study was divided into four stages, the first being the examination of 782 museum specimens (both species). Diagnostic characters were sought other than those having to do with scale patterns in order to separate not only *C. dumetorum* from *C. viridis* but also *C. d. dumetorum* from *C. d. perplexa*. Dissections of male and female genitalia from both species were done using the technique outlined in Ehrlich and Ehrlich (1961), these specimens being chosen from many different localities for possible variation between populations.

The second stage dealt with obtaining specimens (included in the study) from many lepidopterists to clarify the geographic range of these species. Weekend trips were taken during the late spring months of 1967 to extend the range of *C. viridis*.

The third dealt with the selection of several localities in the San Francisco Bay area where ecological and behavioral data for the two species could be obtained and compared during the spring of 1967. Study sites were the following:

Callophrys viridis:

1. San Bruno Mountains, near Daly City, San Mateo Co.
2. 9 mi. NE of Pt. Reyes lighthouse, Marin Co.
3. Del Puerto Canyon, 22 mi. W. Patterson, Stanislaus Co.

Callophrys dumetorum:

1. San Gabriel Canyon, near Azusa, Los Angeles Co.
2. Sand dunes, 1 1/2 mi. E. of Antioch, Contra Costa Co.
3. Brannan Id. State Park, Sacramento Co.

Observations of *C. dumetorum* were also made at Dictionary Hill (San Diego Co.) by Oakley Shields (via correspondence). Specific localities within each study site were chosen for capturing, marking and releasing adults in order to study individual behavior.

The San Bruno Mountains population was observed from February 10 to May 20, whereas Antioch and Brannan Island were visited from April 4 to May 30. Observations were made at the Pt. Reyes study site between April 30 and June 3, and Del Puerto Canyon was only visited twice, in late March and in mid-May. Field observations were made two or three times each week at all but the latter two localities.

Adults of both species occurred at specific hilltop localities in the San Bruno Mountains (*C. viridis*) and Brannan Island (*C. dumetorum*). Marks were made with a black felt pen on the green scales on the wing undersides while the specimen was held within the net. The marks were made so that the specimen could be determined as to date of marking. To avoid loss of individuals immediately after marking, they were held in the net until docile and then released. Marking was done all day for one day at each of the above localities and all recaptured specimens taken throughout the study were recorded as to date and time of day taken. No secondary marking or re-releasing of the recaptured specimens was conducted.

Adults were observed in the lab on several plants including the natural host plants but no courtship, mating or oviposition occurred in the lab.

The fourth stage included the lab rearing of larvae of both species on a series of related and unrelated plants to determine relative specificities and also to note the rate of development on each. The experimental host plants used were:

1. *Lupinus arboreus* Sims. (Leguminosae)
2. *Vicia* sp. (Leguminosae)
3. *Lotus scoparius* Ottley (Leguminosae)
4. *Trifolium obtusiflorum* Hook. (Leguminosae)
5. *Cytisus monpessulanus* L. (Leguminosae)
6. *Eriophyllum staechadifolium* Lag. (Compositae)

7. *Gnaphalium* sp. (Compositae)
8. *Achillea lanulosa* Nutt. (Compositae)
9. *Amsinckia intermedia* F.& M. (Boraginaceae)
10. *Eriogonum fasciculatum* Benth. (Polygonaceae)
11. *Eriogonum latifolium latifolium* Sm. (Polygonaceae)

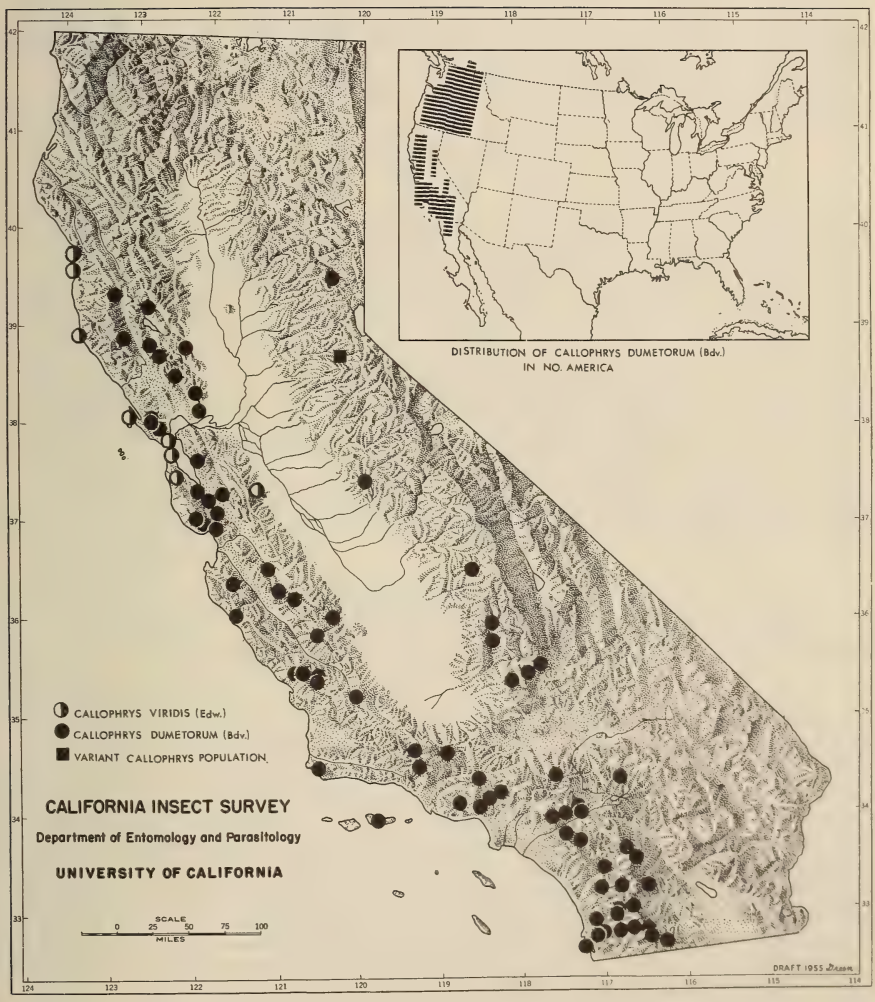
Eggs of *C. dumetorum* were obtained at the Antioch and Brannan Island study sites by taking large numbers of *Lotus scoparius* buds from the field to the lab for microscopic examination. *C. viridis* eggs were taken from the leaves of *Eriogonum latifolium latifolium* at Pt. Reyes.

Glass vials were used, one individual per vial, to rear larvae of both species. Each vial was labeled according to date of egg hatching and arranged by locality in a rack for daily observations. Larval development during the 1967 season was not recorded in detail, but successive instars were accurately recorded in the 1968 lab data using head capsules as an instar number indicator. One or two leaves and several flowers, were placed in each vial with the egg or larva and replaced every other day when desiccation or wilting occurred. Records were kept of the larval acceptance of each plant, especially the time taken to feed, the manner and/or duration of feeding, and of larval refusal to feed. The rate of development on each plant was used as an index for feeding success as well as host acceptance. Lab temperatures during the rearings (1967 and 1968) ranged from 72° to 76° F.

Developing larvae were examined under 45x for distinguishing characteristics and an ocular micrometer was utilized at 32x for larval head capsule measurements. Life history photographs were taken (Figures 1-14) and comparative morphology of the immatures were diagrammed (Figures 15-21B). Larvae were fixed in KAAD for 20 minutes and preserved in 95% ethyl alcohol. Many of these larvae, along with all marked and recaptured specimens have been deposited in the California Insect Survey collection at the University of California, Berkeley.

GEOGRAPHIC AND ECOLOGICAL DISTRIBUTION

Callophrys dumetorum (Bdv.) occupies a wide distribution extending from British Columbia to Baja California Norte, eastward to the eastern edge of the Sierra Nevada in California. Sierra Nevada populations show broad ecological tolerance, occurring as high as 5000'. *Callophrys viridis* (Edw.) is found along the immediate coast in California from the San Bruno Mountains in San Mateo County to Juan Creek, near Westport, Mendocino County (see map 1). Efforts to find this species along the coast in Oregon and the northernmost boundaries of Humboldt County failed. Neither *C. dumetorum* nor *C. viridis* occur in Lower Sonoran areas.



MAP 1 - Distribution of *Callophrys dumetorum* and *C. viridis* in California.

Flight Periods

Populations of *C. dumetorum* fly early in February in southern California whereas adults in San Francisco Bay area populations are not seen until mid-March. At Kusshi Creek, Yakima County, Washington, flight does not occur until May (Newcomer, 1965). The *C. viridis* population studied in the San Bruno Mountains reached a peak flight period on March 7, 1967 whereas the *C. viridis* population found along the sand dunes at Pt. Reyes on the coast in Marin County did not reach a peak flight period until May 14, 1967.

Host Associations

Eriogonum latifolium latifolium Sm., the observed foodplant of *C. viridis* (Brown and Opler, 1967) is only known from the coast of California and Oregon, whereas *C. dumetorum* females have been observed ovipositing on species of *Syrmatium*, *Hosackia*, *Lotus* and *Eriogonum* in southern California (Coolidge, 1924). Newcomer (1965) lists *C. dumetorum* foodplants in Washington as *Eriogonum heracleoides*, *E. compositum* and *E. elatum*. The hostplant of a variant population found at China Flat Campground in the Sierra Nevada is probably *Eriogonum wrightii* Torr. ssp. *trachygonum* (Torr.) Stokes whereas the foodplant of the Del Puerto Canyon population, on the basis of three *Callophrys* eggs found on a single stand in March, 1968, is *Eriogonum latifolium* Sm. ssp. *auriculatum* (Benth.) Stokes.

COMPARATIVE MORPHOLOGY

Evaluation of characters: Callophrys dumetorum and C. viridis

Genital dissections were carried out using specimens taken in two localities for each species. No differences were discovered between the males of *C. viridis* and those of *C. dumetorum*. The male gnathos and valvae appeared to have the same length and the same degree of sclerotization. The females of both species, too, had no structural differences. Careful examinations of sternites VIII, IX and X yielded no differences in size or shape. The signum was examined for possible differences but the amount of sclerotization was great in worn specimens while barely present in fresh ones, evidently a function of age. Male and female genitalia of *C. lemberti* Tilden and *C. comstocki* Henne were also examined but showed no apparent structural differences from one another. Therefore these structures do not provide the answer in determining the validity of species.

Androconial scales from the scent pouches of the males of both species were removed with a minute probe and placed on a slide for examination under 100x. No apparent differences were seen. Labial palpi from both males and females of both species also manifested no structural or scale differences. Of the fourteen characters mentioned by Tilden (1963)

for separating the members of the subgenus, ten were insufficient after examination of 150 specimens of both species. Such a character, for example, is the number of white maculations present on the undersides of the wings mentioned by Barnes & Benjamin (1923), Clench (1944), and Tilden (1963) as a good diagnostic character. But according to Ford (1945), individuals within a single population vary in the number of maculations present and do so even in the European species.

Examination of 596 specimens of *C. dumetorum* and 186 of *C. viridis* (total of 782 specimens) yielded the following characters useful in separating the two species:

1. Females of *C. viridis* are a uniform olive-gray on the dorsal surface, as are the males (fig. 7), varying to a mild olive-brown suffusion in some specimens. *C. dumetorum* females are dark gray-brown with a variable amount of yellow-brown suffusion within a single population as well as throughout the entire flight range (figs. 8, 9).

2. The color of the ventral surface of the wings appears to be a soft or dull yellow-green, varying to olive-green in almost all California populations of *C. dumetorum* (figs. 10-12). *C. viridis*, on the other hand, has deep yellow to blue-green undersides varying only with occasional mild yellow-green individuals within a single population as well as throughout the entire range (figs. 13, 14).

3. The antennae, when viewed dorsally, are black and white in *C. dumetorum* whereas fresh *C. viridis* specimens have all white-scaled antennae.

4. In most California populations of *C. dumetorum*, the green scales on the ventral surfaces of the forewings medially never exceed the Cu_1 vein whereas *C. viridis* populations examined almost always have green scales reaching the Cu_1 or Cu_2 vein of the forewings.

Characters 1 and 2 are evidently the most efficient way to separate *C. viridis* from *C. dumetorum*. The third characteristic is useful only when the specimens being compared are fresh. *C. viridis* antennae tend to lose the white annular scales after a few days of flight, making them appear similar to those of *C. dumetorum*.

Of 68 randomly selected *C. dumetorum* specimens (both male and female) examined from all over California, 4 (5.8%) had the medial green scales on the forewing undersides between the costal and radial veins, 17 (25.0%) had green scales extension restricted to the M_1 vein, 32 (47.1%) had green scales reaching the M_2, 12 (17.6%) had green scales reaching the M_3 and 3 (4.4%) showed green scales reaching the Cu_1.

On the other hand, 75 examined *C. viridis* specimens from Pt. Reyes and the San Bruno Mountains showed 5 (6.6%) with green scales restricted to the M_3, 68 (90.1%) with green scales reaching Cu_1 and 2 (3.3%) with green reaching Cu_2.

Evaluation of characters: Callophrys dumetorum perplexa

Other questions raised concern the validity of *Callophrys dumetorum perplexa*, the atypical race found in southern California. Barnes & Benjamin (1923) recognized this race as a valid one occurring in Los Angeles and San Diego counties southward into Baja California Norte and distinguishable from typical *C. dumetorum* by "the complete or almost complete absence of white markings on the undersides".

Sixty two specimens of *C. d. perplexa* were examined from the vicinity of the type locality (San Diego), 53 of which were males. These males included 6 individuals with no white maculations on the wing undersides (11.3%), 8 with 1 (15.1%), 36 with 2 (67.8%) and 3 specimens having 3 (5.8%).

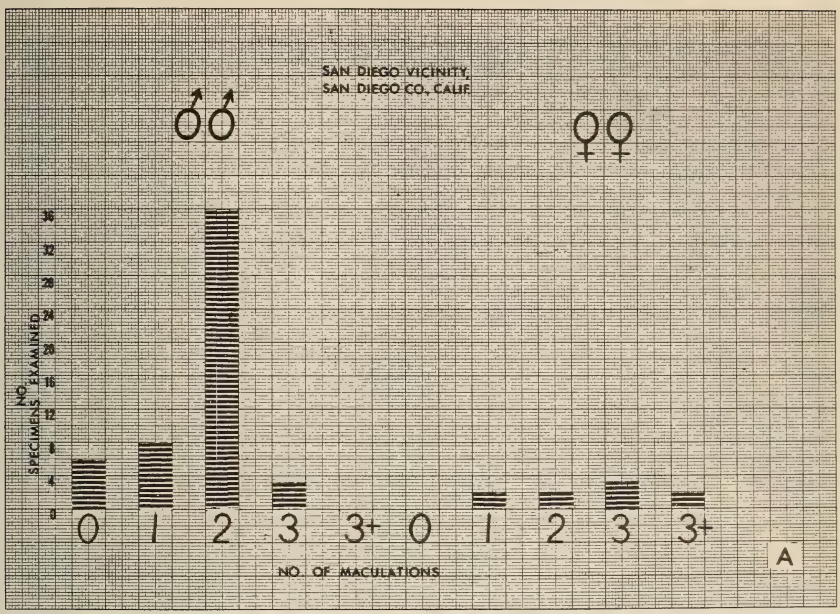
Of the 9 females examined none lacked any maculations, 2 had only 1 (22.2%), 2 had 2(22.2%), and 3 showed 3(33.4%). The remaining 2 females had more than 3 (22.2%) (see graph 1A).

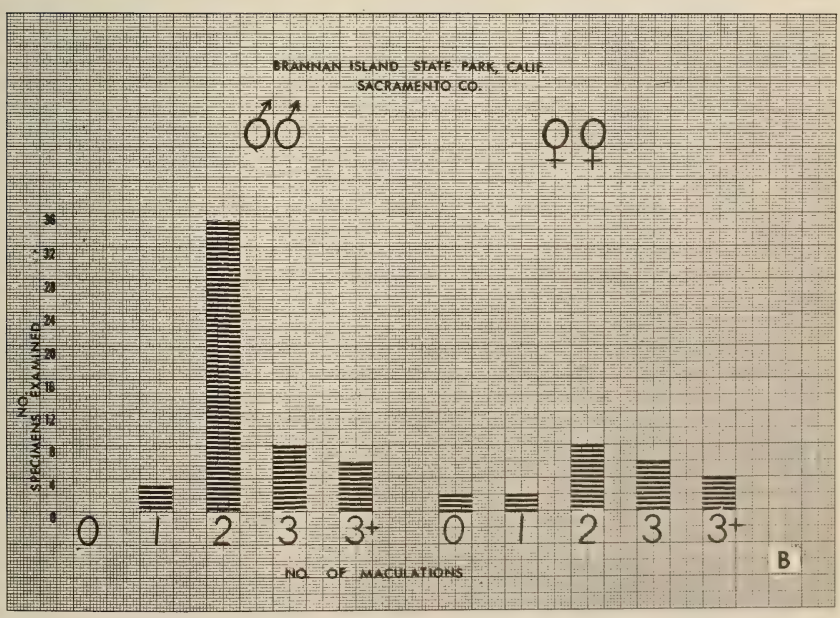
In comparison, a series of 51 males of *C. dumetorum* examined from Brannan Island State Park, Sacramento County, varied from none without any maculations, 3 with 1 (5.9%), 35 with 2 (68.6%), 8 with 3 (15.7%), and 5 with more than 3 (9.8%).

Females of the above population also varied considerably. Of the 21 specimens examined, 2 had no maculations (9.5%), 2 had 1 (9.5%), 8 had 2 (38.1%), 6 had 3 (28.6%), and 3 showed more than 3 (14.3%) (see graph 1B).

The results of the above comparisons suggest that northern California populations are characterized by more spots but not significantly enough to warrant subspecific recognition. Because the males (and most females) of both populations compared showed that the two-spot condition was most prevalent, clinal variation was not assumed to be the case. These maculations, although variable in number, never vary in scale pattern. All are white outwardly and black inwardly.

The invasion of the brown scales on the undersides of the forewings almost to the costa, thus restricting the green scales to the costal margin area, is a character which is supposed to be typical of *C. d. perplexa*. No differences could be found, however, concerning the restrictions of green scales in any of the *C. dumetorum* examined throughout its entire range in California.





GRAPH 1 - A comparison of maculation percentages between two California populations of *Callophrys dumetorum*: A,- Southern California population. B - Northern California population.

The color of the scales composing the fringes of the wings was used as a character by Barnes & Benjamin (1923) separating the *perplexa* form from the typical form of *C. dumetorum*. These fringes were dark and becoming white outwardly, seen in typical *C. dumetorum* as well as in *C. d. perplexa*. This, too, is a variable trait of no significance.

Lastly, Clench (1944) asserted that *C. d. perplexa* is characterized by the "presence of fulvous edging (light brown or dull yellow) on the costa of the forewings ventrally". This is a characteristic also seen in the northern California specimens of *C. dumetorum*.

After review of 554 specimens relative to the above four characters attributed to *Callophrys dumetorum perplexa*, this writer concludes that they do not validate a distinct southern California subspecies because of their presence in the phenotypes of northern California populations as well. Because of the population variation factor present in California, no nomenclatorial distinction is required.

The chief enigma encountered during this study was the discovery of two populations of *Callophrys* (s. str.) that were not clearly either *C. dumetorum* or *C. viridis*. A female *Callophrys* examined from China Flats Campground, El Dorado County, appears to be *C. viridis* although populations representing the *C. viridis* phenotype are not otherwise known to occur in the Sierra Nevada. A second interesting population was found in Del Puerto Canyon in western Stanislaus County. Here individuals match the original description of *C. viridis* with the exception of the black annular scales present on the antennae which fit *C. dumetorum*. In several specimens from Del Puerto Canyon, the green scales were restricted to the area above the subcostal veins as seen in *C. dumetorum*. Since these characters were seen even in fresh specimens, the question must be raised as to whether *C. dumetorum* and *C. viridis* interbreed. Field work throughout the Bay Area where the two come closest together while remaining allopatric indicate that they do not.

In summary, the failure of good evidence of interbreeding suggests the two are reproductively isolated species, and the failure of comparative morphology to reveal reliable criteria for separation of the two indicates other means of confirming their distinctness must be sought. Biological characteristics are therefore examined in this study.

GENERAL BIOLOGY

Most of the species in the subgenus *Callophrys* are single brooded, fly only during the spring and feed on a fairly wide range of hostplants. Females of the Palearctic species *Callophrys rubi* (L.) oviposit on rock-rose (Cistaceae), purging buckthorn (Rhamnaceae), gorse, broom, Dyer's greenweed (Leguminosae), bramble (Rosaceae, dogwood (Cornaceae)

and whortleberry (Ericaceae) (Ford, 1945). Most Nearctic species use members of the buckwheat genus *Eriogonum*, with *C. dumetorum* also using the leaves and buds of legumes such as *Lotus* (some genera recorded in older literature as foodplants for *C. dumetorum*, i.e., *Lotus*, *Hosackia* and *Syrmatium*, recently have been included in the genus *Lotus* (Munz, 1963)). Larvae feed on the leaves and flowers and appear to derive protection from predators due to their cryptic coloration. Pupation occurs in inconspicuous places at the base of the hostplant (Comstock, 1927).

General adult activity is influenced by weather conditions. Clouds blocking the sun, temperatures below 55° F, wind and rain prevent flight activity. During cold weather, adults lean or flatten themselves against leaves, rocks and other flat surfaces. Presumably this is a thermoregulatory mechanism through increased area for insulation (Clench, 1966). On warmer, sunny days flight activity is seen all day.

BIOLOGY OF CALLOPHRYS DUMETORUM

The biology of *C. dumetorum* was studied at four localities, the first being San Gabriel Canyon (near Azusa), Los Angeles County, an area characterized by many chaparral species, including *Eriogonum fasciculatum* and *Lotus scoparius*. The second locality was Dictionary Hill, San Diego County, where observations were made by Oakley Shields in early March for several weeks. The third locality, 1 1/2 miles east of Antioch in Contra Costa County, is characterized by a river delta sand dune flora. The last locality, Brannan Island State Park in Sacramento County is also typified by a sand dune flora. Observations were made on seven days between April 8 and May 11 at the latter two localities.

Adult Behavior

Callophrys dumetorum adults, flying not more than three or four feet above the ground, alighted repeatedly on both *Lotus scoparius* and *Eriogonum fasciculatum* in San Gabriel Canyon. At Antioch, however, females circled specific stands of *Lotus* and landed frequently, ignoring the numerous stands of *Eriogonum latifolium* ssp. present. This lack of interest in *E. latifolium* by *C. dumetorum* females was seen throughout the 1967 flight season and indicates that this plant is probably not used as a host. "Aggressive" behavior was displayed by many males, especially when another butterly species entered the area. The possibility, however, that these flights were merely an attempt to elicit female response should not be ruled out. Not infrequently two *C. dumetorum* males perched within one or two inches of one another and numerous "scuffle flights" or mutual response reactions (whereby males compete for a given territory while in flight) occurred, those individuals involved revolving around one another up to 20 feet in the air, returning to separate leaves

on the same plant or to different plants. Such behavior has been seen in many butterly species and is discussed in detail by Shields (1968).

At Brannan Island 10 males and 9 females were marked and released at 10:00 A.M. on April 13, but of the 104 females and 42 males taken between April 13 and May 2, only 1 marked male was recaptured.

In March 1967, Oakley Shields marked individuals of *C. dumetorum* for 18 days to determine whether males attempt to occupy specific territories. The markings occurred on Dictionary Hill in San Diego County, an area characterized by an abundance of *Brassica nigra*. Of 20 males marked, 7 (35%) were recaptured as follows: 2 after 1 day, 1 after 4 days, 1 after 5 days, 1 after 8 days, 1 after 9 days, and 1 after 18 days. The worn male taken after 18 days was not in excellent condition when marked, giving some indication of the longevity of individuals of this species.

Courtship behavior, observed several times at Brannan Island during the 1967 season, commenced as early as 10:15 A.M. (PST) when an individual male approached a female in flight for several seconds, "forcing" the female to alight. The female, facing the shrub, perched motionless while the male perched on a leaf behind the one occupied by the female and vigorously vibrated its wings. It then moved in a clockwise direction 180° until facing outward in the opposite direction. The entire courtship process lasted no longer than 15 seconds.

As a summary to both Shields' and the present author's observations, mating occurred on the summit in a given territory assumed by a single male. The territories assumed by males of *C. dumetorum* during these observations (as shown by the marking study results) seemed to shift around when many males were present.

Mating behavior was witnessed at 12:30 P.M. (PST) at Brannan Island on April 18, 1967 when one pair was observed for 30 minutes. The female faced the interior of the shrub (*Lupinus arboreus*) with the antennae oriented upwards whereas the male faced the opposite direction, antennae pointing downward. Later, another pair was observed *in copulo* on *Lupinus* from 10:56 A.M. to 11:45 A.M. In April, 1968 a single mating pair was observed displaying the above posture as late as 3:00 P.M. on *Lotus scoparius*. After several observed matings, lab dissections of four females (two of which had been observed mating) were carried out. The two mated females yielded two concentrically-deposited spermataphores in the mouth of the bursa copulatrix indicating that many females mate at least twice.

Oviposition was seen at 10:00 A.M. on May 5, 1967 when a female, perched on a *Lotus* bud, inserted its abdomen well into the bud and deposited a single green egg 90 seconds after

insertion. After turning 180° to face the interior of the same bush, the butterfly flew to another apical bud and oviposited another egg after only 30 seconds. Rapid wing rubbing ensued, followed by antennal vibration. Only when the antennae touched another bud or leaf surface did the female move onto another part of the plant. The female inspected many buds and leaves before attempting to oviposit and flew off if a satisfactory substrate was not found. At no time did a female *C. dumetorum* at Brannan Island attempt to oviposit on *Eriogonum latifolium* ssp. No eggs or larvae were collected from *Eriogonum fasciculatum* in San Gabriel Canyon thus failing to support Coolidge's claim that females accept the latter as a suitable host. Since *E. fasciculatum* is often found in association with *Lotus scoparius* throughout the California coast ranges, *Eriogonum* should not be ruled out as a foodplant for some populations.

Life History

The eggs, approximately 0.4 mm in diameter, are ovoid, finely reticulated, green, and are deposited singly on the host plant (figs 1, 15). Eggs were collected from apical buds of *Lotus scoparius* at Antioch and Brannan Island and kept at room temperature. Emerging larvae were placed on experimental foodplants, and the results of these rearings are presented in Tables 1 and 2.

Morphological changes in each instar in the Brannan Island population corresponded closely to the descriptions given by Coolidge (1924). He showed *Callophrys dumetorum* to have four larval instars, verified by measurement of the head capsule widths of each larva examined. This technique has been found to be useful; there is apparently no overlap of head capsule width between instars in *C. dumetorum* and *C. viridis* larvae. This may be true of most lycaenids since it was also reported by Lawrence and Downey (1967) in larvae of a plebejine lycaenid, *Everes comyntas* Godart.

The following measurements were made on a total of 23 *C. dumetorum* larvae reared and preserved during 1967 and 1968.

	Head Capsule Width (mm)	Body Length (mm)
I instar:	(N=7) 0.15-0.25 (avg. 0.20)	0.92-1.54 (avg. 1.17)
II instar:	(N=1) 0.40	3.20
III instar:	(N=4) 0.70-0.92 (avg. 0.80)	4.80-9.10 (avg. 7.59)
IV instar:	(N=11) 1.23 (avg. 1.23)	11.8-15.5 (avg. 14.8)

TABLE 1 - HOST PLANT ACCEPTANCE AND DEVELOPMENT OF FOURTEEN CALLOPHRYS DUMETORUM LARVAE (1967)

HOSTPLANT	Hostplant locality	Egg	1st instar	2nd instar	3rd instar	4th instar	Color changes	Pupa
Lotus scoparius buds and leaves	Brannan Is. State Pk.	IV-8	IV-13	?	?	V-8	Pink on V-10	Light green to dark brown in 2 hours V-15
Lotus scoparius leaves	"	IV-13	IV-17	IV-20	IV-23	?	Pink on V-10	V-14
Lotus scoparius leaves	"	IV-13	IV-17	IV-20	IV-23	?	Pink on V-10	V-14
Lotus scoparius leaves	"	IV-13	IV-15	?	?	Moved to *E. latifolium* flrs. V-5	Pink on V-5	V-12
Lotus scoparius leaves	"	IV-13	IV-14	IV-17	IV-23	IV-26	Pink on V-6	V-12
Trifolium obtusiflorum flowers	San Bruno Mountains	IV-20 Refr. until IV-25	IV-28	IV-30	V-9	V-14	Pink on V-26	V-29

Eriogonum latifolium latifolium flowers	San Bruno Mountains	IV-20 Refr. until IV-25	IV-28	V-1	?	V-21	Pink on V-28	V-29
Eriogonum fasciculatum leaves	Del Puerto Canyon	IV-20 Refr. until IV-25	IV-28	IV-30	V-15	?		V-26
Lupinus arboreus leaves	Brannan Is. State Park	IV-20 Refr. until IV-25	IV-27 (Died IV-29)*					
Eriophyllum staechadifolium buds and leaves	San Bruno Mountains	IV-20 Refr. until IV-25	IV-27 (Died IV-30)*					
Vicia sp. leaves and flowers	"	IV-25	IV-29 (Died)*					
Cytisus monspessulanus leaves	"	IV-25	IV-27 (Died)*					
Gnaphalium leaves	"	IV-27	IV-30	(Died V-6)				
Amsinckia intermedia, *Achillea lanulosa* leaves	"	IV-20 Refr.	IV-28 (Died V-1)*					

* No attempt to feed

TABLE 2 - DEVELOPMENT OF CALLOPHRYS DUMETORUM LARVAE ON LOTUS SCOPARIUS LEAVES (1968)[1]

Egg	1st instar	2nd instar	3rd instar	4th instar	Color changes	Pupa
IV-7	IV-7	IV-11	IV-16	IV-21	Pink IV-26	IV-30
IV-7	IV-8	IV-11	IV-16	IV-21	Pink IV-26	IV-30
IV-7	IV-8	IV-12	IV-19?	IV-25	Pink IV-29	V-3
IV-7	IV-8	IV-11	IV-21	IV-25	Pink IV-29	V-3

1 Eggs collected April 7, 1968, at Brannan Island State Park, Sacramento County, California on *Lotus scoparius*.

Measurement of the molted head capsule widths at the end of each instar yielded the following ranges:

I instar: 0.15-0.38 mm
II instar: 0.39-0.68 mm
III instar: 0.69-1.10 mm
IV instar: 1.11-1.23 mm

The mature 4th instar larvae of *C. dumetorum* are uniform light yellow-green with subdorsal and lateral white stripes, turning pink just before pupation (figs. 2, 16). Triordinal crotchets arranged in a mesoseries are present on the prolegs (figs. 18A, B) and the crotchets (fig. 18A) are interrupted at the middle by a spatulate lobe, stated by Fracker (1915) to be typical of lycaenid larvae in general. The body, covered by numerous secondary setae, has uniformly rounded segmentation throughout the entire length. The head capsule is heavily sclerotized from the first to the third instars but only the ventral portion of the adfrontal sutures (above antennae) and the ocellar area remain heavily sclerotized in the fourth instar(fig. 17).

Upon hatching, first instar larvae began to skeletonize terminal leaves of *Lotus scoparius*; the second instars did the same. The larvae moved down the stem when the upper leaves died or became completely skeletonized. Mature larvae defoliated the lower branchlets rather than skeletonizing leaves. Larval feeding in general occurred throughout the morning hours in all instars, somewhat actively in the afternoon, tapering off to almost no feeding at all by early evening. Resting larvae positioned themselves on the stem or on the tops of the leaves. Coolidge (1924) stated that the de-

velopment time from egg to pupa in a southern California population was 32 days with larvae feeding on *Hosackia (Lotus)*. Rearing results from the Brannan Island population indicated a 30 to 35 day span on *Lotus*. Although feeding occurred successfully on the flowers of *Trifolium obtusiflorum* and *Eriogonum latifolium latifolium*, development from egg to pupa took as long as 39 days. Feeding on *Eriogonum fasciculatum* leaves resulted in one *C. dumetorum* larva reaching the pupa stage in 36 days.

Unfortunately, a search for field larvae failed and all life history work was carried out in the lab. Thus no parasitism was encountered during the course of the larval rearings and only one mature larva was lost due to bacterial disease.

The pupae (figs. 3, 20, 21B) are a uniform dark or brown-black with the surface texture of the wing pads excessively sculptured, almost forming rows, in contrast to the dorsal surface. A total of 26 were measured, with the length ranging 8.6-10.0 mm (avg. = 9.27mm).

BIOLOGY OF CALLOPHRYS VIRIDIS

Observations on *C. viridis* (reported as "*Thecla dumetorum*") were made in the western part of San Francisco by Williams (1910) who first determined the larval hostplant to be *Eriogonum latifolium latifolium*. In June, 1963 J. A. Powell (*in litt.*) collected *C. viridis* larvae in the San Bruno Mountains in flower heads of *E. l. latifolium* and noted that their pale color with pinkish markings blended quite well with the flowers. Adults emerged in February and March the following season. Further observations on *C. viridis*, emphasizing oviposition behavior, were made by Brown and Opler (1967) in the San Bruno Mountains.

C. viridis was studied extensively during the present investigation at two localities in central California. The first is the San Bruno Mountains near Daly City, San Mateo County. This study site, located about 4 miles from the Pacific Ocean, is characterized by steep rocky slopes with dense, diverse coastal chaparral including an abundance of *E. l. latifolium*. No *Lotus scoparius* was seen here. Observations were made on 14 days between March 2 and May 12, 1967.

The second study site, nine miles northeast of the Point Reyes lighthouse, Marin County, consists of beach sand dunes and associated flora, including *E. l. latifolium*. Like the San Bruno Mountains, no *Lotus scoparius* was found. Cold weather with low clouds and fog was prevalent during the early morning hours (before 11:00 A.M. PST) but most days warmed up considerably by noon when most activity was observed. Observations were made on five days between April 30 and May 28, 1967.

Adult Behavior

As in the case of most *Callophrys* species, *C. viridis* activity is greatly influenced by weather. Flight habits and sunning behavior are similar to those seen in *C. dumetorum*. Observations during the 1967 season were made with difficulty at the San Bruno Mountains study site due to wind and long periods of rain.

The courtship pattern exhibited by *C. viridis* is like that of *C. dumetorum*; a female entering a given male territory was courted by one or more males while in flight. But unlike *C. dumetorum*, males of *C. viridis* in the San Bruno Mountains (due to their lesser numbers) were able to maintain a specific territory with a minimum of shifting around. Two females and two males were marked in late March, 1967, and two males were recaptured on the same plants five days later.

Courtship, mating and oviposition behavior of *Callophrys viridis* was observed at Pt. Reyes. The first two behavioral mechanisms were found to be similar to that observed in *C. dumetorum* at Brannan Island State Park. Oviposition was witnessed on May 14, 1967, at Pt. Reyes at 10:00 A.M.; a single female landed on many stands of *Eriogonum*, tapping several leaves on each with the antennae. Finally, after twenty minutes of flying from plant to plant, the female alighted on an *Eriogonum* leaf; and, after touching the underside of the leaf with the antennae, bent the abdomen underneath and deposited a single green egg near the apical end of the leaf after an estimated 15 seconds. The pilose mat on the leaf underside made it almost impossible to perceive the egg (photo 4).

Host selection by *Callophrys viridis* females was limited at both localities to *Eriogonum latifolium* . This may be due in part to the absence of suitable leguminous plants such as *Lotus scoparius*. *Vicia* sp. occurs at the San Bruno Mountains site, but was found to be unacceptable to *C. viridis* larvae in the lab (see Table 3).

John Emmel (*in litt.*) observed a female *C. viridis* oviposit on *Lotus scoparius* at 11:30 A.M. (PST) in the Sunset Heights district of San Francisco, April 27, 1968. The egg was laid within the apical bud as observed during my study of *C. dumetorum* females. The Sunset Heights locality is characterized by an abundance of *E. latifolium latifolium*, and Emmel reared larvae taken from both plants between June 3 and June 10, 1968 at this site (west of the U.C. Medical Center). According to Emmel, the San Francisco Presidio dunes north of the Veteran's Administration Hospital support both *Lotus* and *Eriogonum* and both are accepted by *C. viridis* females.

No *Eriogonum* in the Pt. Reyes vicinity was yet in bloom while the females were ovipositing. Oviposition on stands

of *E. l. latifolium* which have reached the bloom stage, however, has been recorded by Brown and Opler (1967) in the San Bruno Mountains. In this case the female walked slowly up and down the inflorescence stalk of the hostplant before depositing the egg on a leaf underside. It appears that no matter where the egg is deposited the females of both species of *Callophrys* display numerous inspection flights before the hostplant is chosen.

Life History

The eggs are identical in size, shape and color to those of *Callophrys dumetorum* but on *Eriogonum* are deposited singly on the undersides of leaves near the base of the plant (fig. 4). Both eggs and larvae were collected from the leaves of *E. l. latifolium* at Pt. Reyes in May of 1967 and 1968 and young larvae were offered the same series of plants used to test host specificity in *C. dumetorum*. The results are incomplete, however, due to disease and parasitism encountered during the rearings. The larvae in many cases died before pupation. The results of the 1967 and 1968 rearings are given in Tables 3 and 4.

Body lengths and head capsule widths were measured in 38 *C. viridis* larvae as follows:

	Head Capsule Width (mm)	Body Length (mm)
I instar:	(N=10) 0.31-0.38 (Avg. 0.34)	1.4-2.9 (Avg. 2.25)
II instar:	(N=11) 0.40-0.62 (Avg. 0.57)	3.7-5.5 (Avg. 5.1)
III instar:	(N=7) 0.69-0.99 (Avg. 0.83)	4.9-9.5 (Avg. 7.0)
IV instar:	(N=10) 1.15-1.30 (Avg. 1.25)	9.8-16.0 (Avg. 12.8)

Measurements of the molted head capsule widths yielded the same ranges found for *C. dumetorum* larvae, with possible exception of the upper limit of the IV instar head capsule width.

The first instar larvae examined were light green with setation much like that described by Coolidge (1924) for *C. dumetorum*. Red spots appeared along the subdorsal ridges during the late third instar and remained in the mature fourth instar, corresponding to the description given by Williams (1910). Mature larvae were variable in color; some were light yellow-green with a small amount of pink varying slightly to red, whereas others, even within a single population were whitish marked predominantly with red (figs. 5, 19). Unlike the uniformly rounded segmentation in *C. dumetorum*, larvae of *C. viridis* have pronounced dorsolateral and segmental ridges. The setation, crotchet arrangement and head cap-

TABLE 3 - HOST PLANT ACCEPTANCE AND DEVELOPMENT OF FOURTEEN CALLOPHRYS VIRIDIS LARVAE (1967)

HOSTPLANT	Hostplant locality	Egg	1st instar	2nd instar	3rd instar	4th instar	Pupa
Lotus scoparius leaves	Brannan Is. State Park			V-28	VI-1 (Died: VI-2) parasitized		
Lotus scoparius leaves	"			V-28	VI-1 (Died: VI-2) parasitized		
Lotus crassifolius leaves	Juan Creek Mendocino Co.			V-28	Died: VI-15		
Eriogonum latifolium latifolium leaves	San Bruno Mountains	V-28	VI-8 (Died VI-10)				
Eriogonum latifolium latifolium leaves	"	V-28		V-7 (Died parasitized)			
Trifolium obtusiflorum flowers	"			V-28 (Died: VI-3)*			
Trifolium obtusiflorum flowers	"			V-28 (Died: VI-3)*			
Eriogonum fasciculatum leaves	Del Puerto Canyon			VI-8 (Died: VI-10)			

Eriogonum fasciculatum leaves	Del Puerto Canyon	V-28	VI-9 (Died: VI-15)	
Eriogonum latifolium latifolium	San Bruno	V-28	VI-3	VI-8 (Died: parasitized)
Eriogonum latifolium latifolium flowers	"	V-28	VI-3	VI-9 (Died: VI-10)
Lupinus arboreus leaves		V-28 (Died: V-30)*		
Eriophyllum staechadifolium leaves		V-28 (Died: VI-1)*		
Vicia sp. leaves; *Cytisus monspessulanus* leaves		V-28 (Died: VI-1)*		

*No attempt to feed

sule morphology are identical to those in *C. dumetorum*. The distance between the lateral adfrontal sutures proximal to the clypeus (widest point) were identical for mature larvae of both species (avg. 0.70 mm).

An undescribed species of *Apanteles* (Hymenoptera: Braconidae) was recovered from one second, two third and one fourth instar larvae during the 1967 rearings. Thompson (1944) recorded no parasite record for any species of Nearctic *Callophrys*, but several ichneumonid and tachinid species are known to parasitize *C. rubi* in Europe.

Pupae were examined from Pt. Reyes and the San Bruno Mountains and their lengths are: (N=14) 8.2-9.7 mm (avg. 9.2 mm).

These pupae, unlike those of *C. dumetorum* described above, are brown with a mottled appearance owing to interspersed pale areas, particularly on the wing covers. Both species exhibited finely sculptured ridges, but these appear less pronounced on the lighter colored pupa of *C. viridis* (figs. 6, 21a).

RESULTS AND CONCLUSIONS

Laboratory and field study during the spring of 1967 and 1968 on *Callophrys viridis* and *C. dumetorum* produced interesting similarities between the two. Host selection (based on host availability) in the field proved to be of little use in separation of the two species, while larval characteristics provided the most valuable diagnostic information. The results of the study are summarized as follows:

1. Laboratory inspection of 63 San Diego County *Callophrys dumetorum* specimens showed that the four characters used most frequently to define the so-called subspecies *C. d. perplexa* were found to be present in northern California populations in varying proportions. The degree of difference does not appear to warrant treatment of *C. d. perplexa* as a valid subspecies.

2. The percent difference in green scaling on the wing undersides between *C. viridis* and *C. dumetorum* is consistent enough to distinguish between them; ground color on the female uppersides and the quality of green color on the undersides are also useful in separating the two entities.

3. At no place in the respective distributions of the two species has interbreeding been found to occur, although allopatric San Francisco Bay area populations of both species fly during the same months.

4. The number of individuals marked and released for each species was too small to be of statistical significance, but the number of recaptures along with observations of male

TABLE 4 - OBSERVATIONS ON THE DEVELOPMENT OF CALLOPHRYS VIRIDIS LARVAE (1968)

HOSTPLANT	Hostplant locality	Egg	1st instar	2nd instar	3rd instar	4th instar	Color changes	Pupa
Eriogonum latifolium latifolium leaves	Pt. Reyes	V-10	V-11	V-15	V-23 (Died)			
Eriogonum latifolium latifolium leaves	"		V-10	V-14 (Parasitized)				
Eriogonum latifolium latifolium leaves	"		V-10	V-14 (Parasitized)				
Eriogonum latifolium latifolium leaves	"	V-10	V-14	V-29? (Died)				
Eriogonum latifolium latifolium leaves	"		V-10	V-14	V-23 (Died)			
Lotus scoparius leaves	Brannan Is. State Park			V-23	VI-10	VI-17	VI-19 (pink)	VI-23
Lotus scoparius leaves	"			V-23	VI-10	VI-17	VI-19 (pink)	VI-23

concentration points indicate that courtship behavior for both species is identical. Territories, while sustained by individual males for short times, shift around from day to day when numerical density is high, but appear to be maintained over several day periods in sparse colonies.

5. Aerial courtship and reverse male-female orientation on the host and non-hostplant substrates were seen to occur at least twice by individuals of both species.

6. Mating was observed twice during the morning hours in both species; courtship behavior and oviposition also were witnessed in morning and not commonly during afternoon. Undisturbed males and females of both species remain *in copulo* for at least 30 minutes.

7. Females of *C. dumetorum* select *Lotus scoparius* for oviposition even when *Eriogonum latifolium* is present; while *C. viridis* females select *Lotus* and/or *Eriogonum* when both are present in the same locality. Females of both species spend much time examining and probing the substrate before egg deposition, evidently in relation to the structural quality of the hostplant.

8. In the laboratory, larvae of *C. dumetorum* fed successfully on *Lotus scoparius*, *Eriogonum latifolium*, *E. fasciculatum* and *Trifolium obtusiflorum*; *C. viridis* larvae fed successfully on the first three but failed to accept *Trifolium*.

9. Larvae of both *C. dumetorum* and *C. viridis* matured more rapidly on *Lotus scoparius* than on any other host.

10. Immatures provided the best morphological characters for the separation of these two species. Most noteworthy are the characters given in Table 5.

As stated by Clench (1963), *Callophrys* is an interesting subgenus because of the difficulty in discriminating between the species comprising it. The results of the present study indicate that the morphology of the larvae lend strongest evidence for confirmation of species integrity in *C. dumetorum* and *C. viridis*. It appears that *C. viridis* is not conspecific with *C. dumetorum* as believed by many earlier workers, but rather a species which is ecologically allopatric. Females' host acceptance, especially the preference for *Lotus scoparius* by both species, indicates that the two are closely related. It is possible that *C. viridis* is a more specialized offshoot of *C. dumetorum* as suggested by the more restricted distribution and acceptable host substrates (as seen in the laboratory). But as Clench (1963) asserted, it is also possible to think of *C. viridis* as conspecific with *Callophrys sheridani* (Carpenter) and because relatively little has been recorded on the biology of the latter species, this hypothesis remains to be tested. Further work of a biological nature is needed to clarify confusing issues plaguing this subgenus.

TABLE 5 - CRITERIA USED TO SEPARATE THE IMMATURE STAGES OF CALLOPHRYS DUMETORUM AND CALLOPHRYS VIRIDIS

STAGE	CONDITION	
	C. dumetorum	*C. viridis*
MATURE LARVA:		
a. Subdorsal white stripes	present	absent
b. Subdorsal ridges with red spots	absent	present
c. Ground color	green to yellow green	yellow-green to whitish
d. Subdorsal and segmental ridges	absent	present
PUPA		
Color	dark brown-black	light brown, mottled paler
Wing pad sculpturing	pronounced	weak

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APPENDIX

Materials Studied

Callophrys viridis

Arranged alphabetically, 106 males and 80 females as follows:

CALIFORNIA. Marin Co.: Point Reyes, 2M, 3F, IV-8-51 (C.D. MacNeill), 2M, III-30-56 (W.R. Bauer), 2F, V-16-58 (J. Powell); Point Reyes, 9 mi. NE lighthouse, 4M, 1F, VI-18-66 (R.S. Wielgus), 3F, IV-30-67, 2M, 8F, V-7-67, 7M, 12F, V-14-67 (all G.A. Gorelick). Mendocino Co.: Fort Bragg, 18.6 mi. N, 2M, VI-12-67 (G.A. Gorelick); Juan Creek, betw. Rockport and Westport on Hwy.1M, 4F, VI-9-67 (G.A. Gorelick); Point Arena, 2M, 1F, VI-12-67 (G.A. Gorelick). San Francisco Co.: Lone Mountain, San Francisco, 2M, 5F, III-6-17-1910 (F.X. Williams); Presidio, San Francisco 1M, 1F, IV-5-26 (no collector), 1M, 1F, IV-18-29 (no collector), 1M, IV-10-38 (L.I. Hewes); San Francisco, 1M, V-28-05 (F.X. Williams), 1M, IV-22-16 (K. Coolidge), 2M, IV-26-16 (K. Coolidge), 3M, IV-22-31 (A. Kusche), 2M, 1F, IV-19-34, 3M, 1F, IV-27-34, 6M, 1F, V-8-34, 1M, 2F, V-13-34 (all W. Hovanitz); Twin Peaks, San Francisco, 1F, IV-4-60 (N. LaDue), 5M, 3F, IV-2-60 (R. Stanford), 2M, 1F, LV-13-61 (P.A. Opler). San Mateo Co.: San Bruno Mountains, 4M, II-28-61, 4M, III-10-61, 2M, 3F, III-17-61 (J. Powell), 2M, III-28-61 (N. LaDue), 1F, V-5-61 (J. Powell), 1F, III-9-62 (J. Powell), 1M, 3F, III-31-62 (J.W. Tilden), 9M, 8F, Iv-6-7-62 (J. Powell) 3M, IV-10-62 (J. Chemsak, J. Powell), 2M, 2F, II-26-28-63 (J. Powell), 1M, IV-28-63 (R.L. Langston), 2F, VI-4-63, emerged II-24-64, III-16-64 (reared from *E. latifolium latifolium*) (J. Powell, #63F8), 1F, III-17-66 (A.J. Slater), 4M, III-19-66 (P.A. Opler), 9M, 1F, III-25-66 (P.A. Opler, 1F, IV-13-66 (J. Powell), 5M, 2F, IV-16-66 (P.A. Opler), 4M, 1F, IV-24-66 (R.S. Wielgus), 2M, III-2-67 (G.A. Gorelick), 2M, III-7-67, 1M, 1F, III-22-67 (G.A. Gorelick).

Variant populations: El Dorado Co.: China Flat Campgrounds, 5 mi. S of Kyburz, 1F, VI-5-61 (N. LaDue). Stanislaus Co.: Del Puerto Canyon, 22 mi. W of Patterson, 2M, III-5-63 (R.L. Langston, J. Powell), 1M, 1F, II-22-64 (R.L. Langston, J. Powell, 1M, 1F, IV-6-49, *in copulo* (V.M. Stern) (Adobe Creek); 1F, III-24-67 (G.A. Gorelick), 1M, IV-9-67 (P.A. Opler).

Callophrys dumetorum

Arranged alphabetically, 270 males and 242 females as follows:

BAJA CALIFORNIA. Baja California Norte: Tajo Branch of Cantillas Canyon, Sierra Juarez, 1M, III-23-67 (J. Powell).

CALIFORNIA. Alameda Co.: Berkeley Hills, 1400', NE Oak-

land, 1M, IV-17-62, 1M, IV-15-64 (J. Powell); Oakland, NE, 1M, III-9-30 (G. Heid), 1M, V-1-37, 2F, IV-9-38 (C.W. Anderson). Contra Costa Co.: Antioch, 4F, III-18-57 (P.A. Opler); Antioch, 1 mi. E. 1M, III-19-60 (R. Stanford); Antioch, 1.5 mi. E, (Little Corral) 1M, IV-19-60 (P.A. Opler), 6M, 2F, IV-20-67 (G.A. Gorelick; Mt. Diablo, 1M, IV-9-61 (P.A. Opler). Fresno Co.: Coalinga, 23 mi. W, 1F, V-6-63 (R.L. Langston); Huntington Lake, 1M, V-22-36 (L. Martin). Kern Co.: Havilah, 3000', 2 mi. N, 1M, IV-28-64 (J. Powell); Walker Pass, 1 mi. W, 1M, IV-26-64 (J. Doyen); Weldon, 16 mi. S, 7M, IV-26-64 (R.L. Langston, J. Powell). Lake Co.: Bear Creek, 3 mi. E, 2F, VI-24-67 (P.A. Opler); Middletown, 2500', 4 mi. WNW, 1F V-15-58 (O.E. Sette); Whispering Pines, 3 mi. SE, 1M, IV-4-62 (R.L. Langston). Los Angeles Co.: Altadena, 1M, III-7-26 (J.A. Comstock); Azusa, 2M, IV-3-45 (C.I. Smith); Bob's Gab, nr. Littlerock, 2M, IV-2-54, 1F, IV-7-55, 2M, 2F, IV-9-60 (P.A. Opler), 2M, IV-2-66 (R. Stanford); Cobal Creek Canyon, 2M, III-19-60 (K. Hughes); Desert Springs, 1M, V-5-56 (J. Powell), 1F, V-7-63 (R.L. Langston); Fish Canyon, 2M, III-7-37 (no collector); Glendale, 3M, 1F, III-26-44 (D.L. Bauer); Griffith Park, 1M, IV-10-21 (J.A. Comstock), 2M, IV-14-60 (G.A. Gorelick); Mint Canyon, 1M, IV-16-23 (J.A. Comstock); Pasadena, 1200', 2F, IV-15-11 (F. Grinnell, Jr.): San Gabriel Canyon, 1M, III-1-25 (J.A. Comstock), 2M, III-17-61 (K. Hughes), 2M, 3F, III-20-67 (G.A. Gorelick); San Rafael Hills, 1M, II-13-41, 2M, III-9-41 (D.L. Bauer). Marin Co.: Alpine Lake, 1M, IV-25-58, 1M, IV-17-61 (J. Powell); Carson Ridge, 1M, IV-16-61 (J. Powell); Lake Lagunitas, 1F, V-2-59 (C.A. Toschi). Mariposa Co.: Bear Valley, 2 mi. N on Hwy 49, 1M, 3F, IV-15-61 (P.A. Opler). Mendocino Co.: Fort Bragg, 27 mi. E, nr. Willits, 5M, 1F, VI-9-67 (G.A. Gorelick). Monterey Co.: Hastings Reservation, nr. Jamesburg, 3M, 1F, V-3-58 (J. Powell); Partington Canyon, 1M, 1F, IV-21-51 (P.A. Opler); Stone Canyon, 1M, 1F, IV-21-19 (E.P. VanDuzee). Napa Co. Angwin, 1M, 2F, IV-19-45 (D.L. Bauer). Plumas Co.: Dixie Game Refuge, 5800', 2M, V-17-64 (D.L. Bauer). Riverside Co.: Hemet Lake, 1M, 1F, IV-28-49 (C.D. MacNeill); La Sierra College (campus), 1F, III-12-39 (D.L. Bauer); Lake Mathews, south shore, 2M, III-19-67 (J. Lane); Nightingale, 1M, IV-28-49 (C.D. MacNeill); Perris, 4M, III-4-53 (T.M. Blackman); Sage, 5 mi. S, 2M, IV-16-65 (J. Powell, D. Veirs). Sacramento Co.: Brannan Island State Park, 50M, 150F, IV-7-to V-7-67 (G.A. Gorelick). San Benito Co.: Bitterwater, 5 mi. S, 1M III-30-59 (C.W. O'Brien); Hollister, 24 mi. SE, 1M, 3F, IV-7-62 (O.E. Sette); Paicines, 5 mi. SW (Lime Kiln Rd.), 7M, 2F, III-24-66 (A.J. Slater, J. Powell, R.L. Langston); Pinnacles Nat'l. Monument, 7 mi. W of Jct., 1M, IV-9-66 (P.A. Opler). San Bernardino Co.: Desert Spring, 1 mi. E, 1M, 3F, IV-7-65 (R.L. Langston); Fontana, 8 mi. n (Lytle Creek), 1F, IV-14-65 (C.A. Toschi); Highland, NE (City Creek), 1F, IV-17-65 (G. Buckingham); Lucerne Valley, 5 mi. SW, 4M, 1F, IV-14-64, 3M, IV-15-65 (R.L. Langston); Redlands, 1M, III-15-31 (C.M. Dammers); Upland, 1M, IV-9-57, 1F, IV-28-57 (T.M. Blackman). San Diego Co.: Alpine, 4M, III-31-61 (R.L. Langston); Alpine, 5 mi. E, 1M, 1F, III-31-61 (J. Powell); Anza-Borrego Desert State Park, 1000 Palms Canyon, 1M, III-4-34 (J. Creel-

man); Banner, 3 mi. E (Two Mile Hill), 2M, 1F, III-23-41, 1M, III-22-42, 1M, 1F, IV-8-44, 1M, III-13-57, 1M, III-13-59, 1M, III-11-61 (F. Thorne); Banner, 7 mi. SE (Box Canyon), 2M, III-17-53 (F. Thorne); 1F, III-23-53 (J. Powell). Descanso Ranger Station, 1M, III-31-61 (R.L. Langston); El Cajon, 1M, III-16-35 (C.M. Brown); El Cajon, 2.5 mi. SE (800'), 3M, III-29-52, 1M, III-7-53, 2M, III-15-53 (F. Thorne); Jacumba, 3 mi. W, 1M, III-25-60 (R. Stanford), 2M, III-21-64 (F. Thorne), 3M, III-22-66 (O. Shields); Lakeside, 2 mi. NE, 2M, III-29-61, 2M, 1F, III-13-63 (J. Powell); La Posta Creek (Hwy. 80), 2M, IV-13-63 (F. Thorne); Mission Gorge, 9M, 1F, II-27-52, 2M, III-6-52, 3M, III-21-52, 3M, II-9-53, 3M, II-12-53, 2M, II-14-53 (J. Powell), 1F, III-23-60 (R. Stanford); Mount Laguna Jct., 1 mi. N, 4F, III-26-61 (R.L. Langston, E.E. Lindquist); Mount Laguna Jct., 3 mi. N (Scove Canyon), 2M, III-27-61 (R.L. Langston); Point Loma, 1M, II-12-34, 1M, II-12-35, 1M, II-17-35 (F. Thorne); Ramona, 9.5 mi. NNE (Black Mountain, 4000'), 1M, V-9-65 (O. Shields); San Diego, 1F, III-4-33, 1M, III-18-33, 1F, II-12-35 (F. Thorne); Warner's Hot Springs, 1M, IV-5-50, 2M, III-23-51 (J. Powell). San Vicente Reservoir, 1M, III-19-49 (J. Powell); Scissor's Crossing, 1 mi. W, 1M, III-28-53 (J. Powell), 2M, IV-3-60 (K. Hughes). San Luis Obispo Co.: Atascadero, 4 mi. W, 1F, V-2-62 (J. Powell); Pozo, 6 mi. NE (Black Mountain, 3300'-3600'), 1M, 1F, V-1-62 (C.A. Toschi, R.L. Langston); Pozo, 12 mi. NE (La Panza Camp), 1M, 2F, IV-29-62 (R.L. Langston, J. Powell); Simmler, 1M, III-20-40 (J.W. Tilden, G.S. Mansfield). Santa Barbara Co.: Jalama Beach, 3M, 7F, IV-22-66 (R.L. Langston, J. Powell, A.J. Slater); Sta. Cruz Is., Prisoner's Harbor, 2F, IV-29-66 (R.L. Langston; Sta. Cruz Is., Upper Central Valley, 6F, IV-26-66 (R.L. Langston, J. Powell). Santa Clara Co.: Alum Rock Park, 1M, II-12-64 (R.L. Langston), 2M, IV-21-66 (P.A. Opler), 1M, II-30-67 (G.A. Gorelick); Capitancillos Lake, 1M, III-14-64 (P.A. Opler); New Almaden, 1M, IV-17-64 (P.A. Opler); Palo Alto, 2M, 30 (W. Hovanitz); San Jose, 3M, 1F, V-6-17 (K. Coolidge). Santa Cruz Co.: Boulder Creek, 6 mi. E, 5F, V-17-64 (P.A. Opler); Mt. Ben Lomond, 2M, V-16-65 (P.A. Opler); Santa Cruz Mtns., 2M, V-15-33, 2M, III-14-36, IV-5-36 (J.W. Tilden), 1M, V-1901 (J.G. Grundel), 1M, IV-6-31 (no collector). Sierra Co.: Sattley, 1 mi. W, 1F, VL-17-67 (G.A. Gorelick). Solano Co.: Green Valley, 1M, IV-8-53 (A. Telford). Tulare Co.: Fairview, 9 mi. S, 3M, 1F, IV-27-64 (W. Turner, J. Powell, P. Rude); Johnsondale, 2 mi. E, 1M, IV-27-64 (J. Powell); Sequoia National Park, 2M, 1F, IV-16-30, 1M, V-16-30 (L.I. Hewes). Ventura Co.: Gorman, 5 mi. S, Hungry Valley, 1M, IV-10-60 (G.I. Stage); New Cuyama, 1F, III-28-57 (R.P. Allen); Sespe Canyon, 1F, IV-13-37 (G. Heid). Yolo Co.: Rumsey, 2 mi. NW, 9M, 5F, IV-12-62 (J. Chemsak, J. Powell).

Explanation of figures

Fig. 1 - Eggs of *Callophrys dumetorum* on *Lotus scoparius* bud, Brannan Is. St. Pk., Sacramento Co. (G.A. Gorelick)

Fig. 2 - *C. dumetorum* larvae and pupa (same data as above)

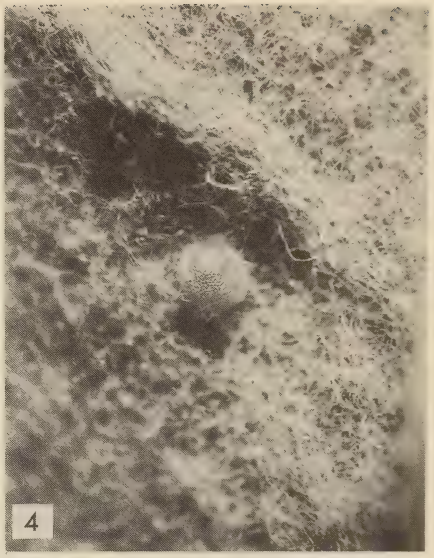
Fig. 3 - *C. dumetorum* pupae (ventral, dorsal views), Pope Creek, Napa Co. (J. Emmel)

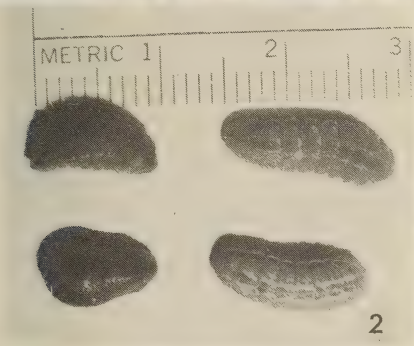
Fig. 4 - Egg of *Callophrys viridis* on *Eriogonum latifolium latifolium* leaf underside, Pt. Reyes, Marin Co. (G.A. Gorelick)

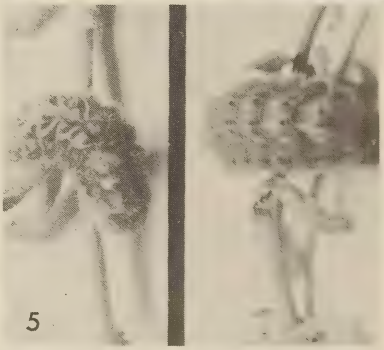
Fig. 5 - *C. viridis* larvae feeding on *Lotus scoparius*

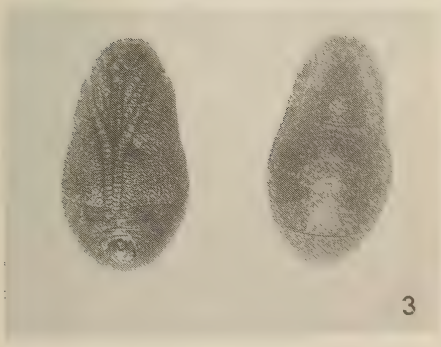
Fig. 6 - *C. viridis* pupae (ventral, dorsal views), San Bruno Mountains, San Mateo Co. (J. Emmel)


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Explanation of figures

Fig. 7 - *Callophrys viridis*, dorsal view, Marin Co. (G.A. Gorelick)

Fig. 8 - *C. dumetorum*, dorsal view, Sacramento Co. (G. A. Gorelick)

Fig. 9 - *C. dumetorum*, same data as Fig. 8

Fig. 10 - *C. dumetorum*, ventral view, Sacramento Co. (G.A. Gorelick)

Fig. 11 - *C. dumetorum*, same data as Fig. 10

Fig. 12 - *C. dumetorum*, ventral view, San Diego Co. (J. Powell)

Fig. 13 - *C. viridis*, ventral view, Marin Co. (G.A. Gorelick)

Fig. 14 - *C. viridis*, same data as Fig. 13


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Explanation of figures

Fig. 15 - *Callophrys dumetorum* egg

Fig. 16 - Mature, 4th instar *C. dumetorum* larva with schematic dorsal view of abdominal segments VII, VIII

Fig. 17 - Head capsule of mature *C. dumetorum* larva

Fig. 18A - Lateral view of 4th abdominal proleg showing crotchet arrangement

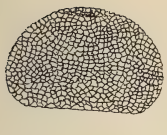
Fig. 18B - Medial view of 4th abdominal proleg

Fig. 19 - Mature, 4th instar *C. viridis* larva with schematic dorsal view of abdominal segments VII, VIII

Fig. 20 - *C. dumetorum* pupa, dorsal view

Fig. 21A - *C. viridis* wing pad sculpturing (ventral view)

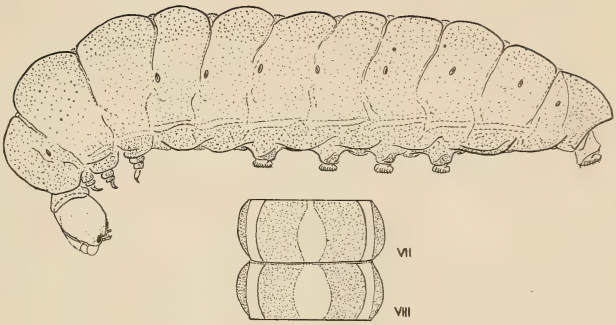
Fig. 21B - *C. dumetorum* wing pad sculpturing (ventral view)



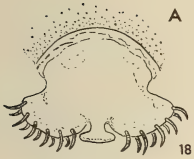
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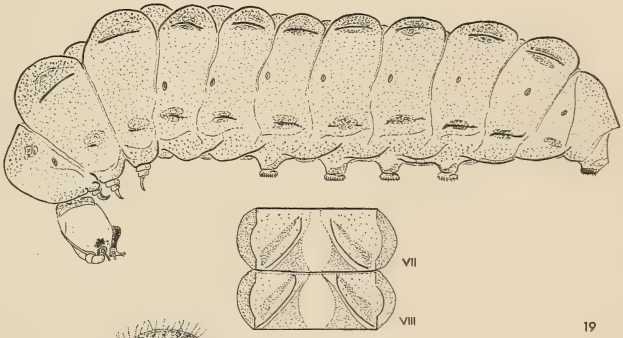
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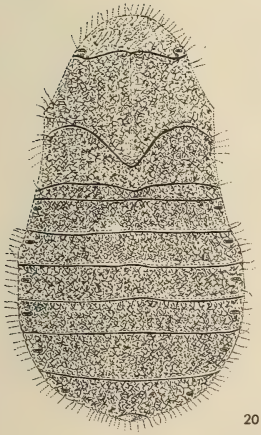
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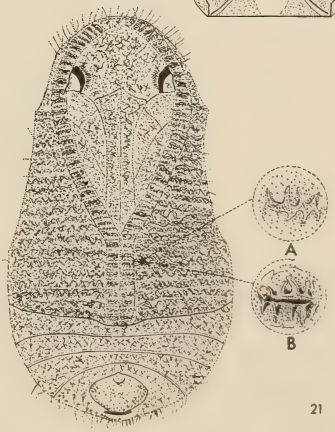
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by CYRIL F. DOS PASSOS

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This issue edited by J. A. Powell.

Supplements to Volume 23 (mailed May 6, 1970):

1. A review of the Megathymidae; by H. A. Freeman; 59 pp.

2. Records, new species, and a new genus of Hesperiidae from Mexico; by H. A. Freeman; 62 pp.

3. On the frequency of butterflies in eastern Brazil, with a list of the butterfly fauna of Pocos de Caldas, Minas Gerais; by Hans Ebert; 48 pp.

Volume 25

JOURNAL

of the

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Herausgegeben von DER GESELLSCHAFT DER LEPIDOPTEROLOGEN



VOLUME 25

SUPPLEMENT 3

BIOLOGICAL STUDIES ON MOTHS OF THE GENUS ETHMIA IN CALIFORNIA (Gelechioidea)

by Jerry A. Powell

10 May 1971

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BIOLOGICAL STUDIES ON MOTHS OF THE GENUS ETHMIA IN CALIFORNIA (Gelechioidea)

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INTRODUCTION[1]

The family Ethmiidae is composed of small to moderate sized moths and is world-wide in distribution, with its greatest diversity occurring in the Neotropical Region. Consisting primarily of the one large genus *Ethmia* the group is distinct in many respects, without close relationship to other families. Ethmiids have in the past been considered as related to or members of the Oecophoridae. Probably they are most closely related to the Stenomidae, and the three groups are considered to be families in the Gelechioidea by present workers.

About 30 members of the genus *Ethmia* have been reared previously, primarily in the Palearctic and in the eastern United States. Nearly all feed externally on Boraginaceae or Hydrophyllaceae during the larval stage, but there have been few detailed studies. Habits of the few other Nearctic genera are equally poorly known: species in *Pyramidobela* feed on *Penstemon* (Scrophulariaceae) and *Buddleia* (Loganiaceae) (Braun, 1921; Keifer, 1936), while the biology of *Pseudethmia* is unknown. Two other species formerly considered to be ethmiids, *Eumeyrickia trimaculella* (Fitch) and *"Ethmia" coloradella* (Walsingham), are fungus feeders and have recently been transferred to the Oecophoridae, a group containing genera with similar morphological and biological traits (Lawrence and Powell, 1969).

In connection with a California Insect Survey project on Ethmiidae, I began to investigate the biologies of these moths in 1961. The study gradually developed into a comprehensive taxonomic one encompassing the New World fauna, some 135 species. Field efforts were particularly directed towards *Ethmia* in California, resulting in the present data on 14 species, which, however, represent only a few species groups in one section of the genus. Thus it seems appropriate to give this detailed biological information separately from the systematic treatment of the genus as a whole. A general review of biological knowledge for the family is given in that study (Powell, 1971).

It became evident early in this work that some species are diurnal and others nocturnal. It was one of the aims of the investigation to clearly define which are diurnal in order to assess the significance of this phase of the moths' biology in systematic relationships. Adults of both diurnal and nocturnal species are sometimes encountered in numbers during the daytime, and at times it is difficult to distinguish between active flight behavior and reactionary movement in response to disturbance by the observer. There-

1 This study was in part made possible through assistance from National Science Foundation Grants GB-4014 and GB-6813x, "Comparative biology in relation to systematics of Microlepidoptera", 1965-1970.

fore, criteria I have used for defining natural activity rhythm in the diel cycle have been the timing of mating, oviposition, and the "quiescent posture" by moths in captivity.

The resting posture during periods of activity was distinguishable from that shown by moths in the "quiescent posture" assumed during the inactive phase of the diel cycle. In the "quiescent posture" the wings were tightly clasped against the abdomen and the antennae were held back alongside the body, under the costal edges of the wings. The insects crouched low, almost appressed to the substrate, with the legs widely outstretched. Moths temporarily not moving during activity periods held the wings somewhat loosely spread from the sides of the abdomen, and the antennae projected outward, at right angles to the body axis or somewhat forward, usually moving slowly. At the same time they stood up higher above the substrate with the legs less widely outstretched.

The "quiescent posture" was exhibited at night by all individuals of species which mate and oviposit in daytime. There was not a temperature correlation with darkness, since heating indoors kept the temperature above 18° C until midnight or so, while it often remained as low as 12° during the early daylight hours.

As a result of this study, it is now known that diurnal species possess small eyes and usually very dark integument and vestiture. Thus the behavior pattern can be predicted on the basis of preserved specimens. The eye size has been quantified and described elsewhere (Powell, 1971). In a few species the eyes are intermediate in size, and my observations on *Ethmia arctostaphylella* suggest that this is correlated with a tendency towards crepuscular behavior.

Techniques

The present data originate from field collections of either late instar larvae or adults which were retained alive for oviposition. The moths were taken at lights or by netting them during daytime or at dusk. Adults were transported from the field in cotton-stoppered glass vials and were caged in one-gallon glass breeding jars. The housing methods and details of the container were essentially the same as used and described in studies of tortricine moths (Powell, 1964). The jars proved more satisfactory for ethmiids than for Tortricinae because oviposition by *Ethmia* usually occurred on the host plant or on the nylon mesh used as a ceiling on the cage (figs. 11, 12), rather than on the sides of the glass container. Insofar as possible the jars were placed adjacent to an open window, exposed to natural lighting, including direct, dappled sunlight (filtered through tree foliage) during part of the day. Observations after nightfall were made by means of a flashlight provided with a cover of red construction paper. This light source usually did not attract or otherwise disturb the moths.

In the field larvae were generally detected by hand-searching suspect plants. A few species could be effectively collected by beating (certain perennial plants) or sweeping, but most of the present species live in concealed shelters on low, herbaceous hosts. Larvae were transported from the field in polyethylene bags and generally were housed in closed containers with cut sprigs of host plant. Newly hatched larvae in the laboratory were usually housed in 25 x 100 mm salve tins on small bouquets of foodplant in water vials plugged by cotton. In few cases greenhouse plants were used for early instar establishment. Larger larvae were housed in plastic sandwich boxes or 85 x 100 mm jars with cuttings of foodplant.

To provide fresh plant material for species reared from eggs, plants from the collection site were transplanted to pots in a greenhouse, bouquets were placed in water, or cuttings of the same or a closely related plant were obtained from the University of California, Berkeley, Botanical Garden at the time of egg hatch. Transplanting (perennial *Phacelia*) or cuttings in water (annuals) proved satisfactory for early instars since these plants usually persisted well for 2-3 weeks. However they matured in advance of field conditions, and later instars were provided with plants from the Botanical Garden unless the original collection site could be revisited conveniently. For field collected late instar larvae, cuttings were either offered as bouquets in water or were refrigerated (± 4° C) and later offered without water. This required frequent replenishing of provisions.

Soft paper toweling, folded many times, and sometimes cut sections of dry *Yucca whipplei* floral stalks were provided as pupation substrates. A tendency to wander and burrow into soft bark and similar substances has been reported in the literature for several *Ethmia*.

Rearing was conducted at laboratory temperatures (usually varying about 12-20° daily). Pupae in diapause were in some cases housed in an outdoor screen cage at Berkeley or in an open shed at Russell Property, near Lafayette, California, an inland station where greater climatic extremes more approximate field conditions of inland parts of California.

The only previous biological information concerning the species discussed below is the report by Dyar (1902) that *E. semitenebrella* had been reared from *Cercocarpus* in Arizona. Hosts of three species must have been known to Keifer (1936) who described the pupa of *albitogata* and mentioned larval characters of two other species, but he gave no information on their biologies. Therefore I attempted to discover the host association through observing moths in the field. Adults of both diurnal and nocturnal species tend to stay close to the larval foodplants, and each of the present species has proven to be specific to members of one plant genus so far as known. Following field collection, I caged females with a small bouquet of the suspect host. If no clear association had been ascertained, a varied menu of

possible oviposition substrates was offered. Females exhibited only a poor oviposition response or none at all, if caged without the appropriate host. The fact that most previous recorded plants for *Ethmia* are Boraginaceae and Hydrophyllaceae helped to restrict my selection, during field searches. However, in one case this restricted thinking hindered the eventual discovery of an unrelated plant as the host.

Detailed comparison of eggs was not attempted. Photographs showing general habitus and placement on the plant were taken for most species. High magnification scanning electron micrographs were executed only for *scylla*. In scheduling for photography eggs were usually stored in a refrigerator (4° C) for several days, which delayed maturation of developing larvae for a period about equal to that in cold storage.

When sufficient numbers were available, larvae representing each instar were preserved, using KAAD for a few minutes, followed by storage in 95% ethyl alcohol. Head capsules representing previous instars of living individuals were recovered and were used in measurements for estimating the number of instars, along with the preserved larvae.

Detailed morphological descriptions of the larval stages have not been made. The larvae are briefly characterized, with special reference to instar differences, following the biological discussion of each species. Abbreviations are as follows (see fig. 7): HC = Head Capsule, a measurement of maximum width as seen from above is given; ThSh = Prothoracic Shield; Pin = Pinacula; D = Dorsal band a narrow color stripe in later instars of most species, from pro- or mesothorax to ninth abdominal segment; DL = Dorsolateral pigment bands lateral to D, above the spiracles; L = Lateral band, a broad area around and below spiracles; LV = Lateroventral band, a weakly developed pigment band below L, above the legs; AbdCr = Abdominal Crotchets, an extended mesoseries or mesopenellipse in all the present species; AnCr = Anal Crotchets. All measurements were made through a disc micrometer at 27x or 54x magnification and are given in mm, based on specimens distended in KAAD. Measurements are based on six or more specimens except where indicated otherwise, with the number in brackets []. Color features were noted from living larvae. Integumental colors of *Ethmia* fade during preservation.

Morphological characteristics of the pupae are variable, and only limited comparison between species is attempted owing to inadequte series for most species. Most of the species examined here are quite similar.

Constant Biological Characters

Several features of the biology and behavior appear to be consistent among all species, and these are not discussed for each species. The eggs are deposited singly, cemented to the substrate by an affixed area nearly as long and wide as the egg. The egg is more or less rectangular in outline, nearly as thick as wide; it does not flatten out onto the substrate, but conforms to minor irregularities, sometimes altering its shape a little (e.g., fig. 12). At hatching larvae chew a round, ragged hole at the micropylar end, sometimes well off center. The hole is about one-half the diameter of the egg, and no further feeding is done on the eggshell by newly hatched larvae. When disturbed or dislodged, larvae of most species, especially in later instars, react by wriggling violently backward. A few species feign death and fall, immobile, to the substrate. Based on head capsule measurements, there appear to be five instars in several species, but data are too fragmentary to determine the number with certainty for most species. At least in *brevistriga* and *scylla*, and probably *plagiobothrae* and *albitogata*, there are five, while large species such as *discostrigella* and *arctostaphylella* probably undergo six, at least in some individuals (figs. 1-6). At maturity larvae of probably all species wander, often having been found to burrow into soft, woody substrates to pupate. Data on specimens I have examined, especially of several species reared by F.D. Parker at the University of California, Davis, from trap nests[1], indicate this is a widespread habit. During my study larvae usually were confined in salve tins or 35mm pill boxes for pupation, and most did not burrow into yucca pith, using unnatural situations such as a corner of the container. At emergence the pupal shell remains inside the cocoon, held in place by the hooked setae of the anteriorly directed "anal legs" (figs. 8, 9) (in all species except *scylla*). The cremaster such as is normally developed in most Lepidoptera at the tip of the abdomen is vestigial. Eight frail setae are present in a constant arrangement for all species, but these do not aid in anchoring the pupa. The degree to which the "anal legs" of the pupa are appressed to the abdominal venter or angled outward varies within species, possibly affected by the shape of the cocoon.

Acknowledgements

Grateful acknowledgement is made to Helen K. Sharsmith, formerly of the University of California, Berkeley, Herbarium, who provided many of the plant identifications associa-

1 Sections of *Sambucus* stems, 45 cm in length, which had been stuck into the ground, with a 1.5-4 mm hole drilled in the exposed end (Parker and Bohart, 1966).

ted with this study. Through Mrs. Sharsmith, Lincoln Constance, University of California, Berkeley, determined most of the *Phacelia*, and Francia Chisaki Hommersand, Chapel Hill, North Carolina, identified some of the *Amsinckia* species. Thanks are due Anton Crist and other personnel of the University of California Botanical Garden, who have been cooperative in providing cuttings of native host plants many times during the past decade. Photographs of eggs *in situ* were executed by A.A. Blaker, Scientific Photographic Laboratory, University of California, Berkeley. Stereoscan Scanning Electron Microphotographs were executed through the cooperation of T.E. Everhart, Electronics Research Laboratory, University of California, Berkeley, through support from National Science Foundation Grant GB-6428 and Grant No. GM15536 from the National Institutes of Health. Assistance with field collections, particularly during early years of the study, was given by several persons, whose help is appreciated and acknowledged by mention in the text; but special thanks are due C. Don MacNeill, Oakland Museum, and Catharine Toschi Tauber, Ithaca, New York. Where not otherwise indicated, all collections and observations are my own.

Ethmia coquillettella Busck

Ethmia coquillettella Busck, 1907, Proc. Ent. Soc. Wash., 8:95.

This species has been collected at only a few widely scattered sites in arid parts of California and interior British Columbia during the 70 years since the original specimens were taken in the vicinity of Los Angeles (Powell, 1959, 1971). Considerable interpopulational variation is exhibited, and study of more material will be necessary in order to confirm that just one species is involved. This and related species in the southwestern United States, which have the palpi clothed with stiff, erect bristles, are believed to be diurnal.

I have not been able to confirm the foodplant of *coquillettella* with certainty. The moths have been encountered only in small numbers, and not in close association with any plant. Larvae accept *Phacelia* and *Nemophila* in the laboratory, and on two occasions have been reared to the fifth instar but not to maturity. One larva was collected in the field on *Phacelia distans*.

Study areas: - 1)Pinyon Flat, 16 road miles southwest of Palm Desert, Riverside Co.; 1 male, 3 females taken in flight, 11:00 A.M. - 1:00 P.M., April 13, 1963 (C.A. Toschi and J. Powell), 3 females retained alive (63D19). 2) Railroad Canyon, 4 miles northeast of Elsinore, Riverside Co.; 1 male, 2 females at flowers of *Coreopsis californica* (Compositae), 11:45 A.M. - 2:00 P.M., April 13, 1965 (C.A. Toschi and J. Powell), 2 females retained alive (65D1). 3) Del Puerto Canyon, 23 road miles west of Patterson, Stan-

islaus Co.; 4 males, 1 female taken in flight, 12:30 - 3:00 P.M., March 25, 1969, 2 males, 1 female retained alive (69C94); 1 larva on *Phacelia distans*, April 27, 1969 (69D59). At Pinyon Flat the moths were taken near *Mentzelia* (Loasaceae), a possible nectar source, and immature *Phacelia distans* var. *australis*; at Railroad Canyon a mixed stand of *Phacelia cicutaria* var. *hispida*, *P. distans*, and *Nemophila menziesii* grew near the collection site; while at Del Puerto Canyon, *Phacelia distans* and *Amsinckia intermedia* were suspect hosts.

Adult behavior: - Collection records indicate a single flight period in early spring, in California from mid February to mid April, varying with conditions of locality and season. Laboratory observations have been sporadic but tend to confirm the diurnal behavior pattern indicated by adult morphology and field collections. In the breeding jar moths were active during the day and occasionally at night if direct lighting was on them. Mating was not observed.

Females from Pinyon Flat were caged with *Phacelia* and *Mentzelia* in a 85 x 100 mm jar, but on the day following collection the jar became water soaked during transport in a field ice box. Two of the females recovered and were transferred to a one-gallon jar; but probably they had been weakened as it appeared that neither left the floor of the container. Only 9 eggs were deposited, on the cardboard jar floor.

Females from Railroad Canyon were also housed in an 85 x 100 mm jar under field conditions. A bouquet of *Phacelia cicutaria*, *Nemophila*, and a *Coreopsis* flower was offered as possible oviposition substrate and nectar source. A natural photoperiod rhythm was not provided, and, with exposure to indirect and direct lighting late in the evenings, activity periods apparently were irregular. A total of 40 eggs was deposited by one or both females, in part during early hours of night (8:00 P.M. - 2:00 A.M.) and during early morning hours (2:00 A.M. - 8:00 A.M.). A few eggs were place on Leaves of *Nemophila* but most were deposited around corners of the container floor.

The adults from Del Puerto Canyon were caged in more suitable conditions, in a one-gallon breeding jar provided with a bouquet of immature *Phacelia distans*, *Amsinckia* in flower, and immature *Epilobium* sp. (Onagraceae), housed in natural photoperiod. Males lived only 1-3 days, but the females survided 10 days, depositing 70 eggs, nearly all during the first two days of confinement. Both sexes were inactive at night, remaining in quiescent posture until 10:00 - 11:00 A.M. The period of highest activity appeared to be 1:00 - 3:00 P.M., although individual movement occurred in dappled sunlight until 6:00 P.M. The moths displayed a stronger positive phototropic response than some other diurnal species. Oviposition was observed between 1:30 and 3:00 P.M., and a few eggs were deposited later in the day. The female selected roughened surfaces in the side of the

jar towards the light. She walked about on undersides of *Phacelia* leaves and on the nylon screen ceiling with the abdomen extended and curled downward, probing at the substrate. Usually she ran a few "steps", then probed two or three times, sometimes slightly to the side. A quiescent pause of several seconds followed each egg deposition.

Of the 70 eggs, about 75% were deposited around the s side of the jar towards the light; and of the total, 60% were placed on the masking tape around the floor and 15% on the nylon. Only 8 eggs were deposited on the plants, all on the undersides of *Phacelia* leaves adjacent to the light side.

Egg. - Eggs were uniformly subrectangular, varying from 0.46 x 0.76 to 0.41 x 0.82 mm in outline. During development all turned pink by the third day, and a somewhat darker reddish by the 7th to 9th day. Incubation time varied from 10 days in April in the field (65D1) to 11-12 days in March at room temperatures (69C94). Emergence sometimes occurred well off center of the micropylar end.

Larva. - Considerable difficulty was encountered in inducing young larvae to establish and feed, relative to my experience with other *Ethmia*. A distinct preference for flower buds was shown, and it appeared that leaves were unsuitable for development. A continuous supply of immature flowers was not provided, and this may have been a critical factor in the failure of larvae to reach maturity under laboratory conditions.

First instar larvae (63D10) placed on *Phacelia distans* from Pinyon Flat which had been in refrigeration 16 days failed to survive. Some fed a little at the base of buds, but none successfully established themselves.

One and two day old larvae (65D1) were placed on fresh buds of *Nemophila maculata* and *Phacelia tanacetifolia* from the Botanical Garden; larvae at first began feeding on both plants, either in the buds or in crotches of leaflets or sepals. All eight larvae placed on the immature, scorpioid spikes of the *Phacelia* established successfully and reached at least the second instar. The inflorescences were tightly curled, and by the second day frass was visible between the appressed, hirsute buds. Larvae continued to feed inside the buds during the first 12 days; on May 7, 10 day old plant material from the Botanical Garden was added when the larvae were 11-12 days old. Three days later only three larvae had moved to the more recently offered buds. On May 14, the 3rd and 4th instar larvae were moved to fresh *Phacelia tanacetifolia* from the Botanical Garden. By this time the plants had bloomed and subsequent feeding took place mainly on smaller leaflets, often those adjoining flowers.

The ephemeral character of the *Nemophila* flowers prevented establishment of all but one of the first instar larvae.

This larva succeeded in burrowing into an unopened bud, preventing it from further development, and fed on the pistil and stamens for 11 days; it then migrated to a new, less developed bud and began feeding. The 15 day, 3rd instar larva left the *Nemophila* (which was partially collapsing in the water vial) and was transferred to the *Phacelia*. At the Botanical Garden the *Nemophila* was drying by the time the larvae were 19-20 days old, which, together with the difficulties encountered in establishing on this plant, suggests that *Nemophila* is not a suitable host. Nutritionally the *Nemophila* flowers appeared to be adequate since the one larva was as mature as the most advanced of those feeding on *Phacelia* at each inspection.

On May 24, about 30 days after hatching, laboratory observations were interrupted by a vacation camping trip. The remaining larvae were carried in a salve tin and were subjected to greater temperature fluctuations than in the laboratory and to drying of the foodplant. Fresh *Phacelia* leaves were added from San Bernardino County, California, and Coconino County, Arizona, but the final larva died by June 4 while an early fifth instar.

Unfed first instar larvae (69C94) were placed on *Phacelia distans* from Del Puerto Canyon, which had been kept in water 12-13 days; establishment was affected by burrowing into unopened buds. After 4 days an accumulation of fine frass was noted in the dense hairs of the inflorescence. On April 19, the 10-12 day old 2nd and 3rd instar larvae were transferred within their shelters to vials with fresh *Nemophila menziesii* from Santa Clara County. Although the original *Phacelia* had become blackened and mouldy, after 3 days there were no signs of feeding on either flowers or leaves of the *Nemophila*. The 13-15 day old, 3rd instar larvae were then offered fresh *Phacelia tanacetifolia* from the Botanical Garden, and all established new shelters. Subsequent feeding occurred in buds on bouquets of this host. Fresh sprigs were added every few days, as it did not keep well in water, and two exposures to badly withered plants probably affected larval development. Owing to a field trip intervention, surveillance was terminated on May 9, and the 30-32 day old larvae were preserved. They apparently were penultimate and immature last instar individuals which had not grown during the preceding 4 days due to the condition of the plant.

Inspection of *Phacelia distans* at Del Puerto Canyon on April 27 (when laboratory larvae were about three weeks old) revealed only one larva of *coquillettella*. This individual was provided *P. distans* for 8 days, then *P. tanacetifolia*. However, foodplant conditions were intermittently poor, and the larva died on May 7 in the final instar.

Since feeding took place on buds of *Phacelia tanacetifolia* in water and the developmental rate was similar to

that of *Ethmia brevistriga*, it is assumed that *P. distans* and *P. cicutaria* might serve as suitable hosts at the study sites. However, as with other species in the diurnal group, a definite preference for feeding in unopened flowers was shown, and it may be that fresh buds are necessary to provide sufficient nourishment to complete development.

First instar: Length 1.6 mm; HC 0.20-0.22 mm, brown, ocellar area black; ThSh brownish; integument and setae unpigmented.

Second instar: Length [1] 4.0 mm; HC [4] 0.30-0.35 mm, brown, frontal area slightly paler; ThSh, thoracic legs, lateral spots on prolegs, and anal shield, brown; Pin minute, dark, integument otherwise unpigmented. AbdCr 8-10; AnCr 7-8.

Third instar: none preserved; HC and ThSh dark brown, integument pattern pale purplish.

Fourth instar: Length [2] 8.2-8.5 mm; HC [3] 0.67-0.74 mm, brown, mottled with pale areas; ThSh mottled, brown with darker spots; Pin blackish; D white (not unpigmented) with thin, median deep ochreous streaks; DL mottled, pale purplish to brownish olive, large, distinct white rings encircling pinacula; AbdCr 7-10 (usually 8-9); AnCr 7-8.

Fifth instar: [5] Length 8.0-12.0 mm (none mature); HC 0.74-0.82 mm, markings strongly contrasted; integument colors similar to penultimate, ThSh brown with darker spots; D and pinacula rings of DL more contrastingly white, DL, DV darker purplish or olive, L slightly whitish or unpigmented, with or without faint ochreous streak; AbdCr 9-14 (usually 12-14); AnCr 11-12.

Ethmia scylla Powell

Ethmia scylla Powell, 1971, U. Calif. Publ. Ent., in press.

Three localities along the inner Coast Range of central California comprise the known range of *scylla*. I collected the first specimen on March 18, 1959, at about the time my review of the poor state of knowledge of *Ethmia* in California had gone to press (Powell, 1959). However, exactly ten years were to elapse before I was able to solve the mystery of *scylla's* biology, the search having been hampered by a preconceived notion that some Borage or Hydrophyll must be the hostplant. Although the adults resemble *Ethmia brevistriga*, and thus might be expected to feed on a *Phacelia*, this species proves to be unique as the only member of the genus known to use Scrophulariaceae and further the only member of a Nearctic or Holarctic species group which does not possess the peculiar "anal legs" of the pupa.

Study areas. - 1) Russelmann Park, north slope of Mt.

Diablo, 1100 feet, Contra Costa Co.; adults numerous, April 2, 1960 (J.M. Burns and J. Powell); adults sparse, April 6, 1962, 3 males, 2 females retained alive (62D2). 2) Raines Park, Del Puerto Canyon, Stanislaus Co.; adults sparse, March 5, 1963,(R. Langston and J. Powell), 4 males, 2 females retained alive (63C1); negative results checking *Amsinckia intermedia*, April 30, 1963; adults abundant, March 19, 1969, 4 males, 3 females retained alive (69C90); adults common, March 25, 1969, 2 females retained alive (69C90); larvae abundant in flowers *Collinsia heterophylla* April 27, 1969 (69D60). 3) Three miles northwest of Rumsey, Yolo Co.; adults sparse, March 8, 1964.

Adult behavior. - The species has a single annual flight, in moderately early spring, from late February to early April, varying two to three weeks with seasonal conditions. This is well ahead of the bloom period of the foodplant. All three localities are deciduous oak-digger pine scrub forest situations. At Russelmann Park the moths appeared to fly around poison oak, *Rhus diversiloba*, in the manner of *Ethmia albitogata* at the San Bruno Mountains, where *Amsinckia* grows in close association with the poison oak clumps. Adults of *scylla* sometimes perched on poison oak foliage where they resemble bird droppings. The association at Raines Park proved to be a general one; the *Collinsia* is abundant in semi-shaded spots on north slopes around various shrub growth including *Juniperus*, *Arctostaphylos*, and *Ceanothus*.

Adults were observed in the field between 11:00 A.M. and 4:00 P.M. Two mating pairs were taken, one at 3:40 P.M. on April 2, 1960. Mating did not occur in the laboratory.

In captivity moths intermittently abandoned the quiescent posture between 8:30 and 10:30 A.M., but continuous activity did not begin before 11:00. It lasted until about 4:00 P.M., after which movement gradually subsided, ceasing by 5:45 or 6:00 P.M., at about sunset. As indicated by oviposition, the height of activity was not concentrated into a brief period and did not strongly vary between cloudy and clear days, extending from 12:00 or 1:00 P.M. to about 4:00. Generally adults were strongly positively phototropic, and oviposition by the 1962 females seemed to corroborate this. However, when *Collinsia* was offered (69C90), eggs were more evenly distributed, with more than half of those deposited on plants having been placed on a *Collinsia* in the center of the jar, rather than on those nearer the light source.

In earlier collections various immature, low growing annual plants from the collection sites were included in the breeding jars. The 1962 lot was also provided with a few small *Plagiobothrys nothofulvus* from Lake County. Several small *Amsinckia intermedia* in bloom were included in the 1963 trial. One or more of the 62D2 females deposited 5 eggs on the nylon ceiling and 30 on the cardboard floor (which was roughened, with fibres protruding, the result of

removal of masking tape), 80% concentrated on the side of the jar towards the light. In experiments with other *Ethmia* the cardboard floor was sometimes used by old, weak females, but in this case it was selected on the first day of confinement, judging from the incubation period.

The 1969 moths were offered an array of *Amsinckia* in early bloom, and immature plants of both *Phacelia distans* and *Collinsia heterophylla*. The latter had been observed in high numerical density in the vicinity of female moth concentration. In the breeding jar females complied by displaying a distinct selection not only for *Collinsia*, but for the leaf axils. A total of 124 eggs was deposited by 4 females; exactly half were placed on the nylon screen, while nearly all the remainder (60) were laid in leaf axils of *Collinsia*. Most were on the upperside of the petioles, but some were placed in axils where secondary leaves originated, so that they were sometimes affixed to undersides of secondary petioles when tucked into the primary axils. They were distributed along the height of the plant, but tended to be concentrated (60%) on the middle axils, which bore the secondary leaf growth. One egg was deposited on the upperside of a leaf blade. One was deposited on each of the *Amsinckia* and *Phacelia*.

Females tended to concentrate on the screen ceiling towards the light source, but wandered during oviposition. The probing action of the extended ovipositor was more or less continuous at about 30/minute. One female was observed in this behavior on the nylon, traveling some 7 cm during 2.5 minutes; finally after 4 minutes she extruded an egg onto the apparently uniform nylon mesh. Deposition of an egg required 1-2 seconds, after which the female usually quickly moved several cm without probing the ovipositor, then stopped in a stationary pause, sometimes moving to the light side to do so. Results of individual female's efforts were not tabulated, but 3 females deposited a combined total of about 100 eggs in 2 days.

The moths did not survive long under cage conditions, males living 3-7 days, and the females only 3-5 days.

Egg. - (figs. 13-17) The egg is characteristically elongate, cylindrical, with the chorion strongly reticulated with ridges which bear no microstructural modifications. Eggs varied from 0.30 x 0.59 mm to 0.27 x 0.61 mm.

During development the eggs changed color, to pale orange by the 2nd day, bright pink by the 3rd day, and gradually darker reddish before the larvae became visible prior to emergence. Incubation required 10 days (62D2) and 8-9 days (69C90) at laboratory temperatures.

Larva. - In order to confirm the host selection displayed in oviposition behavior, separate lots of newly hatched larvae (69C90) were segregated in 32 x 90 mm shell vials and were offered cut terminals including flower buds,

of four menus: a) *Collinsia heterophylla* alone, b) *Phacelia distans* and *Amsinckia intermedia*, c) *Collinsia* and *Phacelia* d) *Collinsia* and *Amsinckia*. Six larvae were isolated in each vial, and three additional larvae were added to c) and d) after three days. In each case the only successful establishment occurred in flower buds of *Collinsia*, with about 33% of the individuals successful. The *Amsinckia* did not fare well under the conditions and was essentially wilted within three days, while the *Phacelia* remained in good condition for at least five days. All plants were in poor condition by eight days, and the a) vial became diseased by the 11th day. There was no evidence that feeding occurred on either *Collinsia* leaves or any part of the *Phacelia* or *Amsinckia*. Surviving larvae, along with others established in separate containers with *Collinsia* bouquets were fed subsequently on flowers of *Collinsia heterophylla* which had been taken in immature condition on March 25 at Raines Park and kept in water, where the plants developed to full bloom. Additional *C. heterophylla* from the Botanical Garden was provided to nearly mature, 24-26 day old larvae.

Larvae of all instars fed within developing flowers. If a bud was entered, no feeding occurred on sepals except in excavating an entrance hole; ovaries, stamens, and corolla parts were fed upon, preventing the bud from opening. Usually partially or fully opened flowers were used, and ovaries were consumed, along with basal portions of the corolla, but no feeding occurred on the sepals. After a few days young larvae migrated to new flowers, leaving the wilted corolla *in situ*. In the field this resulted in several withered and abandoned flowers on a given plant, indicating the presence of one larva. Normally only one or two flowers on any given tier were affected. The larva moved upward as the inflorescence elongated, rather than working around the inflorescence until all available flowers at one tier level were exhausted.

In contrast to some species of *Ethmia*, the larvae curled and feigned death at the slightest disturbance. They were thus difficult to manipulate during transfer from one flower to another, as they could not be induced to spin silk onto the probe, and even if transferred with a damp brush or forceps and balanced in an immobile posture on a new flower, would almost always drop off upon moving again. However, they showed a strong tendency to wander up vertical objects, and usually migrated back up flower stems and reestablished on their own when a given flower became exhausted.

Development proceeded rapidly relative to other *Ethmia*. Individuals provided with *Collinsia* buds in good condition reached the second instar by 8-10 days, and the third instar by 11-13 days. The fourth instar was not preserved, but all larvae had passed through it by 25-27 days. Final instar, 25-29 day old larvae were preserved on April 25 and 27, and the last mature larva prepared for pupation on April 29, 31 days following beginning of egg hatch.

On April 27 the Raines Park site was revisited and larvae were found abundantly in *Collinsia* flowers (69D60). Development was retarded relative to that in the laboratoty. No larvae were preserved on this date, but after six days storage at outdoor temperatures, a larval sample showed three instars, 3rd, 4th, 5th, in a 2: 4: 5: ratio. At eight days all three were still present, in the ratio 1: 3: 10. Only full grown larvae remained on May 9 (12 days after collection), 51 days following the original collection of females in the field. Thus height of oviposition probably occurred March 19-26, and most larvae reached maturity in the field about May 3-9, an average lapse of 45 days.

There are five clear-cut larval instars, according to unsexed head capsule measurements (fig 4).

First instar: Length 1.2-1.4 mm; HC 0.16-0.18 mm, light brown; ThSh narrowly light brown, well defined; body yellowish, integument unpigmented.

Second instar: Length 2.0-2.5 mm; HC 0.25-0.27 mm, dark brown; ThSh well defined, brown; integument with pale DL color, faintly defined paler D and rings around Pin which are barely visible; AbCr 8-9, essentially a complete circle; AnCr 7-8.

Third instar: Length 3.2-4.8 mm; HC 0.38-0.43 mm, dark brown, slightly mottled paler; ThSh brown, slightly mottled darker posteriorly; D well defined; unpigmented except slight median pink line; DL pink, weakly defined; LV pinkish, scarcely defined; Pin dark, well defined; AbdCr 9-11; AnCr 8-9.

Fourth instar: Length 5.5-7.2 mm; HC 0.51-0.68 mm, light brownish mottled with darker brown; integument pattern as in final instar, paler; D well defined, unpigmented except median pinkish line; DL fairly well defined; Pin black, surrounded by unpigmented circles; AbdCr 10-14 (mostly 10-11); AnCr 8-9.

Fifth instar: Length 8.8-12.0 mm; HC 0.82-0.98 mm, orange with faint brown mottling; ThSh sclerotized as median lateral spot and posterolateral blackish patch; integument pattern well defined pink on whitish-unpigmented or purplish on pinkish-unpigmented (probably varying with petal colors consumed), D well defined with median pink streak; DL well defined, dark, defining unpigmented circles around the black Pin, L unpigmented; LV fairly well defined; AbdCr 14-18, rarely 20, usually nearly uniordial; AnCr 16-17; one or two secondary setae in LV group on abdominal segments 1, 2, 7, sometimes 8.

Pupa. - Small blocks of dry *Yucca whipplei* floral stalks were provided and were used by all successfully pupating individuals. Each spun the cocoon in a narrow gallery running parallel with the grain of the wood. It

appeared that abandoned *Cossonus* galleries were appropriated and at times somewhat enlarged. Emergence trackways led out to split ends of the substrate and each was divided into two chambers by silken caps, one near the surface and one recessed several mm, which was of slightly less diameter than the pupation chamber, located at the anterior end of the cocoon. Cocoons ranged about 5.4-5.7 x 1.3-1.7 mm and were simple, without any interior meshwork.

Pupae (fig. 10) ranged 4.7-5.2 mm in length and were simple, without functional cremaster, anal legs, or other setation. The ninth segment was unmodified and fused to the eighth at mid venter. The spiracles were small, simple, 0.35 mm in diameter. Evidently the cocoon shape retains the pupa at emergence.

Pupae formed by larvae in May, 1969, failed to emerge, although housed at Russell shed, where conditions stimulated emergence of *plagiobothrae* (69D58) in the same winter. Pupae were still viable appearing when extracted from cocoons after 17 months.

Ethmia brevistriga brevistriga Clarke

Ethmia brevistriga Clarke, 1950, Jour. Wash. Acad. Sci., 40:163.

The nominotypic subspecies is known only from localities along the immediate coast of California.

Study areas. - 1) Laguna Puerca, San Francisco; adults common in association with *Phacelia distans*, April 7, 1961; 5 males, 5 females retained alive (C.D. MacNeill and J. Powell) (61D2); larvae on *P. distans*, May 6, 1961 (61D2); larvae on *P. distans*, May 24, 1961 (61E21). 2) Lobos Creek, San Francisco; adults in association with *P. distans*, April 7, 1961; 1 male, 1 female retained alive (61D2).

Adult behavior. - A single, well defined flight was shown in 1960 and 1961 at San Francisco, from mid March to mid April, prior to beginning of flowering of *Phacelia distans*. Six pairs were caged with a bouquet of *P. distans*. These moths showed a slightly later diurnal activity period than *albitogata*, housed under similar conditions. Individuals of *brevistriga* were not active before noon, and even by 1:30 P.M. only limited movement and no oviposition was occurring. The height of activity appeared around 3:30 to 4:30, continuing until about sunset, around 6:00 P.M. By 7:00 they had become sluggish and only flew straight down if dislodged. None moved at night. This species showed a greater tendency to perch on the host plant than any of the others studied. About 60-80% of the individuals rested on the plant, even at night.

Mating was witnessed twice. A pair was swept *in copulo*

at Lobos Creek at 3:00 P.M. They had been flying or were perched on the tip of a *Phacelia* branch. They were still in coition at 7:00 P.M. following transport from the field. Housed in darkness, they remained *in copulo* until at least 11:00 P.M. The second pair mated sometime between 1:00 and 5:30 P.M. on the first day after confinement; after 5:30 they remained inactive, clinging to an upright pin all night. Separation occurred between 9:30 and 10:10 A.M.

Oviposition by several females was observed, between 3:30 and 4:00 P.M. It probably took place earlier, and one female exhibited apparent oviposition behavior at 5:15 P.M. Characteristically females crawled over the uppermost foliage or moved spirally up a stem, with the abdomen distended, moving rather slowly and vibrating their antennae. The substrate was tapped 4 or 5 times with the papillae anales prior to deposition of an egg. A period of quiescence (18 to 45 seconds) usually followed each egg after which the moth resumed its crawling or flew to a new spot. Periods of crawling on the screen were sometimes interspersed with those of oviposition.

About 80 eggs were deposited by the females during the first two days of confinement. It appeared that none were laid on the plant after the third day. Nearly all were concentrated in the upper 5 cm of foliage, mostly around the buds. The eggs on the inflorescences were not nested deeply into crevices, but were placed between the plant hairs (figs. 21-23). The uppersides of upper, young leaves and the main stem were also used as oviposition sites. Eggs placed below the upper 5 cm of foliage were on the stem. None were placed on the undersides of the leaves except on the main midrib. Some oviposition after the third or fourth day of confinement took place on the cardboard floor of the jar.

Egg. - The eggs ranged 0.31 x 0.53 mm to 0.30 x 0.60 mm and as thick as wide (fig. 23). When first deposited they were pearly white; after about 48 hours they turned yellow. Prior to hatching the dark larval head capsule became visible. Eggs hatched April 19-20, after about 11 days at room temperature.

Larva. - Several *Phacelia distans* plants from Laguna Puerca were planted in pots in a greenhouse prior to emergence of the first instar larvae. These plants, which matured sooner than those in the field, were used for observations on behavior of young larvae.

First instar larvae migrated upward and commenced feeding at bases of flower buds. In one instance a one day old larva had bored through the sepals of a small unopened bud. The first external evidence of established larvae appeared by 4-6 days in the form of small frass accumulations in the flower heads.

By the 14th day the insectary plants had bloomed com-

pletely, but the larvae, in the third and fourth instars, had prevented development of some buds in which they fed. In each case the larva had formed a well concealed shelter between the rows of flowers on the scorpioid spike, hidden primarily by the dense plant hairs. The shelters were held together by a weak network of silk. Feeding occurred in the currently opened flowers and unopened buds, usually all the way out to the terminal end of the inflorescence. Not all of every flower was consumed, and some were still in apparent bloom. Damage to the inflorescence was not evident externally, and the frass accumulations were the only visible evidence of the larvae.

On May 5, 17 days after commencement of hatching in the laboratory, the Laguna Puerca site was investigated. Three third instar larvae were found, in shelters similar to, but less extensive than, those in the greenhouse. Field plants had bloomed only about half way along the inflorescence. Larvae were located just basad of the current bloom, feeding on the flowers with developing seed. Frass from these shelters was not visible from the exterior, evidently having been dispersed by factors such as wind. All larvae were moved to newly potted plants at this time, but the plants did not survive. The remaining larvae were transferred to salve tins with cut inflorescences two days later.

By the 24th or 25th day following hatching some larvae had reached the last instar. One larva on one of the original potted plants reached the last instar by the 28th day, when it was preserved.

A third examination of the field colony was made on May 24, 36 days after laboratory eggs began hatching and 6 days after the first cocoon was spun in the greenhouse. Larvae were found to be fairly common in areas where the *Phacelia* was more sparse, although the shelters were as inconcpicuous as they had been three weeks earlier. By this time field larvae were mostly penultimate instar; a few were antepenultimate, and only one was in the final instar.

All larvae reached the final instar by the eighth day after the second larval collection, and the final larvae which had not spun cocoons were preserved June 6, 60 days after the original adult collection.

There appeared to be five instars, on the basis of unsexed head capsule measurements (fig. 3).

First instar: Length 1.5-1.7 mm; HC 0.18-0.20 mm, brown; ThSh and anal shield pale brown; integument and setae unpigmented.

Second instar: None preserved; HC 0.27-0.36 mm [5], brown.

Third instar: Length 4.3-6.0 mm [3]; HC 0.42-0.47 mm, dark brown; ThSh brown; Pin minute, dark; DL sometimes with a trace of pale brownish, AbdCr 8-11; AnCr 9.

Fourth instar: Length 5.3-9.3 mm; HC 0.66-0.77 mm, usually slightly to considerably paler brown than third instar, lightly mottled; ThSh paler brown; Pin small; integumental pigment well developed, D white, DL brownish, broad, extending below spiracle; L narrow, whitish; LV with little pigment; AbdCr 9-13; AnCr 9-10.

Fifth instar: Length 9.0-13.2 mm; HC 0.86-0.95 mm, orange brown, mottled; ThSh pale brown with dark spots; D white (not unpigmented), DL broad, as in fourth instar, darker, purplish; Pin small, in DL surrounded by whitish circles; L white; AbdCr 15-18; AnCr 16-17. Segment A9 with 6-8 tiny secondary setae on LV.

Pupa. - Pupation and successful development took place in small beetle galleries in split sections of *Yucca whipplei* inflorescence stalk, in one instance about 15 mm into the yucca, although not much excavation of the matrix by the *Ethmia* larvae was involved. Pupation also occurred in a corner of a salve tin, in flower heads, and in folds of paper toweling. The only successful emergence occurred from one of the latter. Those in the flowers and salve tin dessicated prior to development.

The cocoon surface was papyrus-like, without much loose internal silken mesh. The pupae ranged 5.4 to 5.6 mm in length. The anal legs were short, the free portion only 0.22-0.23 mm long, appressed to abdomen, with 16-20 setae situated broadly over the distal end.

Ethmia brevistriga ardicola Powell

Ethmia brevistriga ardicola Powell, 1971, U. Calif. Publ. Ent., in press.

This race occurs at inland stations, mostly in the mountains marginal to the deserts. From the following fragmentary data and larval morphology, *ardicola* appears to have essentially the same biological characteristics as the nominate subspecies.

Study areas. - 1) Hills two miles northeast of Lakeside, San Diego Co.; adults taken in flight without definite plant association, March 13, 1963 (J.A. Chemsak and J. Powell); 5 males, 1 female retained alive (63C2). 2) Pinyon Flat, 16 road miles southwest of Palm Desert, Riverside Co.; adults abundant at flowers of *Cryptantha ?circumcissa* and flying in association with *Phacelia distans* subsp. *australis* April 7, 1963 (R.L. Langston, C.A. Toschi and J. Powell); 3 females retained alive (63D6); April 12, 1963, 4 males 5 fe-

males retained alive (63D17); young larvae on *P. distans* var. *australis*, April 13, 1963 (63D20).

Adult behavior. - This subspecies has about the same seasonal flight period as its coastal counterpart, despite the higher elevation of the inland sites (up to 5000 ft.). Moths of 63C2 were caged in a gallon breeding jar in the field with a bouquet of *Cryptantha* and kept under variable conditions until the fourth day. They did not begin activity until about 12:20-1:00 P.M. with the room temperature at about 18° C, even though an *Ethmia minuta* male in the same jar had been active for two hours. As with *b. brevistriga*, the greatest activity seemed to be about 4:00-4:30 P.M. The last individual ceased activity and entered the quiescent posture at 5:40 on one afternoon, but several were active until 6:10 (dusk) on another; and moths were observed with the antennae in active position as late as 7:00 P.M. on the tenth day after collection.

Males lived 8-13 days and the female 13 days, but only 2 eggs were deposited, those on the glass side of the container. Presumably absence of *Phacelia* resulted in failure to initiate oviposition. Moths of 63D17 were caged in an 85 x 100 mm jar with a bouquet of *Phacelia* and *Cryptantha* but became water soaked in transit in an icebox from the field laboratory April 14; several recovered and two females lived until the sixth day following collection. Eggs were deposited April 14-17 on both upper and lower surfaces of *Phacelia* leaves, not on buds, and on *Cryptantha* foliage, dry *Cryptantha* flowers, and on a dead *Ethmia* male.

The three 63D6 females deposited 1, 6, and 10 eggs in their individual, dry vials during the 2-3 days they lived.

Egg. - Eggs deposited in dry vials were evenly oval, tapering slightly towards both ends, not as rectangulate as in related species. The width and length ranged 0.33 x 0.63 to 0.36 x 0.63 mm.

Eggs of 63D6 were stored in dry vials in warm conditions of a field laboratory and hatched in 8 to 9 days; those of 63D17 were stored under moist conditions and variable, cooler temperatures (including one to two days in a field icebox) and hatched in 8 to 13 days.

Larva. - First instar larvae hatching from eggs on the plant material, *Phacelia distans* subsp. *australis* and *Cryptantha circumcissa* were left *in situ* in the inflorescences. Most established feeding sites successfully on *Phacelia* buds, although leaf material was eaten by two individuals. None fed on the *Cryptantha*. Those from dry vials were placed on flowers of *Phacelia*, and the flower parts served as food throughout their growth.

The second instar was reached by about the sixth day by most larvae; thereafter developmental rates varied, owing

to variation in condition of the plant material.

The *Phacelia* stems in one of two 63D17 lots began to rot a week after the larvae hatched, and these larvae were transferred to fresh, although mature, *Phacelia distans* from Stanislaus County. They continued development, using mature flowers; both the flower parts and developing ovules were eaten. One larva reached the final instar by the 30th day.

A second lot was retained on the original *Phacelia* material from Riverside County, which remained in good condition for about 27 days after the larvae hatched. However, all flower parts were eaten by this time. Larvae fed entirely on the half of the flowers towards the center of the spike, or by cutting a hole through this side and eating the center portions out, taking whole developing seed or only their inner half. By the 33rd day the plant had dried excepting the stems, and larvae starved in the final three instars.

Laboratory reared larvae averaged somewhat smaller and were considerably paler than *b. brevistriga*.

First instar: Length 1.3-1.4 mm, HC 0.19-0.20 mm, almost colorless except ocellar area black.

Second instar: None preserved; HC 0.27-0.36 mm [3], pale brownish.

Third instar: Length 3.6 mm [1]; HC 0.46-0.49 mm, dark orange-brown; ThSh pale tan; integument, setae and crotchets unpigmented.

Fourth instar: Length 6.4 mm [1]; HC 0.63-0.68 mm [4], orange-brown, mottled; ThSh orange-brown; integument, setae and crotchets unpigmented; AbdCr 10-11; AnCr 10.

Fifth instar [2]: Length 7.5-8.0 mm; HC 0.79-0.85 mm, orange, mottled; ThSh orange-brown; integument pattern similar to *b. brevistriga* but much paler and reduced; D whitish (not as distinctly white); DL dark pinkish or rosaceous; setae and crotchets unpigmented; AbdCr 14-16; AnCr 14-16.

Ethmia albitogata Walsingham

Ethmia albitogata Walsingham, 1907, Proc. U. S. Natl. Mus., 33:109.

This species is known from only a few localities in central California. It is closely related to *E. plagiobothrae*, and it was not until differences in hostplants and larvae were discovered that distinguishing morphological characters in the adults of the two species were recognized.

Study areas. - 1) San Bruno Mountains, San Mateo, Co.;

adults common, Feb. 28 - March 1, 1963 (C.D. MacNeill and J. Powell); 5 males, 2 females retained alive (63B9); larvae on *Amsinckia lunaris*, May 3, 1963 (63E1). 2) Pt. Reyes, Marin Co.; larvae on *Amsinckia spectabilis*, April 31, 1967 (G.A. Gorelick) (67D149). 3) Arroyo Mocho, 15 miles southeast of Livermore, Alameda Co.; adults common, Feb. 22-24, 1968 (C. D. MacNeill and J. Powell); 5 males, 4 females retained alive (68B178); negative results checking *Amsinckia* and *Plagiobothrys*, April 27, 1969; adults sparse, Feb. 21, 1970.

Adult behavior. - The moths fly in early spring, late January to early March. Presumably germination of the host plant has begun, but I have been unable to locate young *Amsinckia* when the moths are flying. Adults (63B9) were caged with a bouquet of *Phacelia californica*, a suspect host; while 1968 adults were provided with young *Plagiobothrys nothofulvus*, owing to a misidentification of the moth. The correct foodplant was never offered as an oviposition substrate and stimulus.

The moths exhibited a definite diurnal activity rhythm, but neither mating nor oviposition was observed. Individuals from the San Bruno Mountains commenced activity earlier, beginning to abandon the quiescent posture by about 9:30 A.M., three hours after daybreak, with the outside temperature at 9-11° C. During the following two hours all adults engaged in some movement. One female was observed to take water in this matinal "pre-activity" period. Continuous activity, with moths mostly crawling at the side of the jar towards the sunlight, took place between 12:00 and 4:00 P.M. By 4:30 some moths ceased movement, and by 5:30, with the last rays of sunlight on the jar, most individuals had assumed the quiescent posture. Adults from Arroyo Mocho, by contrast remained inactive until 10:30-11:30 A.M., even when the container was transported by car 15 miles to Berkeley. However, they remained active later, till 6:00-7:00 P.M., through the dusk period. Outside air temperatures were warmer during the 1968 observations, ranging to 24° C maximum compared to 15-17° in 1963. Moths in both groups generally displayed a longer activity period than some of the other diurnal *Ethmia*, and they became active quickly if exposed to direct light at night.

Males lived 2-6 days, females 6-9 days, following collection in the field.

In 1963 no eggs were deposited by captive *albitogata*. Presumably the *Phacelia* did not provide adequate stimulus, since cage conditions were comparable to those extant during successful oviposition by other diurnal *Ethmia*. The 1968 females laid only 35 eggs; again absence of *Amsinckia* probably adversely affected oviposition behavior. Of the total, 28 eggs were placed on the helical, ribbed portion of a horizontal, screw-cap vial which held a moisture wick and *Plagiobothrys* bouquet. The remaining eggs were deposited on *Plagiobothrys* leaves (5 upperside, 2 underside).

Egg. - The eggs did not differ superficially from those of *plagiobothrae*. No measurements or photographs were executed. Incubation required 11-11.5 days.

Larva. - First instar larvae were placed on *Plagiothrys nothofulvus* from Arroyo Mocho. Uprooted young plants had been placed in water vials 12 days previously, and after initial die back of lateral leaves, survived well for the duration of the experiment and were sending up floral stalks by the time of larval hatch. Most larvae did not establish on this host. It appeared that those situated on new terminal leaves were unable to penetrate the thick pubescence; when transferred to the undersides of basal green leaves, where pubescence was less dense, most still did not feed successfully. Two individuals accepted the *Plagiobothrys* and fed about 7-9 days, reaching the second and third instar. Feeding occurred in the form of small skeletonized areas, with a thin silk envelope between the new leaves of the terminal growth. Although the plants remained in good condition more than three weeks after transferral to the water vials, no flowers had begun to open by the time the larvae succumbed in what appeared to be starved condition. The unavailability of flower parts rather than the wrong host genus may have been the critical factor in the failure of the larvae to mature.

At San Bruno Mountains in 1963 close association of adult flight with several clumps of poison oak (*Rhus diversiloba*) on rocky outcroppings, enabled discovery of larvae on *Amsinckia lunaris* there in early May. At this time, about 60 days after the height of observed adult activity, the plants were in full bloom, and larvae of the final three instars were present. There was variation between *Amsinckia* colonies from 75% penultimate and none full grown to 50% mature final instar and the remainder young final instar.

All larvae were found inside inconspicuous shelters formed in the flower spikes, similar to those of *E. brevistriga*. Larvae moved along the upper side of the scorpiod spike, webbing the flower parts together above the larval galleries. Feeding took place on the whole inner side of the flowers. Developing ovules and ovaries of unopened flowers were consumed, and even sepals were eaten by larger larvae. Portions of the flowers on the outer half, visible from the exterior of the inflorescence, were untouched. Petals were mostly above the area of feeding and remained intact, without discoloration or wilting. Some feeding occurred on the inflorescence stem; in one instance it was cut entirely through.

Shelters were not evident from the exterior, but affected inflorescences could be detected by frass clinging to the older, unoccupied portion of the spike where elongation of the stem caused separation of the partially eaten flowers, exposing silk. Frass apparently was entirely retained within active parts of the shelter, not visible from the exterior.

Larvae were placed in plastic sandwich boxes with small bouquets of *Amsinckia*. However, the viscid plant did not keep well and mould developed within three days. *Yucca* pith was added as a pupation site, but the colonies became affected with disease and no larvae pupated.

As in *plagiobothrae*, head capsule measurements did not enable definition of all instars (fig. 2). In both species either the second instar head capsules were not recovered or a greater relative size increment occurred between the first and second than in other *Ethmia*. Moreover, these two species exhibited two color phases in the final instar, a characteristic not observed in related species. Head capsule measurements showed only a very slightly larger average in the paler of the two phases.

First instar: (None preserved in healthy condition) HC 0.18-0.22 mm, dark brown; integument, including pinacula, unpigmented.

Second instar(?): [1] (Not preserved in distended condition) HC 0.33 mm; dark brown; integument unpigmented, Pin slightly darker; AbdCr 9-10; AnCr 9.

Third instar (?): [1] (Not preserved in distended condition) HC 0.50 mm; brown, unmottled; ThSh brown laterally, unpigmented mesally; D whitish, DL brownish gray, L unpigmented, LV pale grayish, Pin dark, not defined by pale areas; AbdCr 9-10; AnCr 8.

Penultimate instar: [4] Length 7.5-7.8 mm; HC 0.57-0.60 mm, dark brown, paler above labrum, not mottled; D scarcely distinguishable, whitish, DL pale grayish (not distinct as in fourth instar *plagiobothrae*), L unpigmented; AbdCr 6-9 (usually 8-9); AnCr 6-7.

Final instar: Length 10.2-13.0 mm (rarely, teneral?, 7.7 mm with integumental pigment reduced); HC 0.83-0.96 mm, strongly mottled; similar to *plagiobothrae* but paler, with the two color forms not as distinguished: (a) (HC avg. 0.88 mm) D pale without yellow-orange spots, DL well defined, dark to pale gray; (b) (HC avg. 0.90 mm) D pale with segmental yellow-orange spots, DL and LV pale gray; Pin small, well defined, dark; AbdCr 10-20 (usually 12-16); AnCr 12-16.

Ethmia plagiobothrae Powell

Ethmia plagiobothrae Powell, 1971, U. Calif. Publ. Ent.; in press.

Although discovered only about ten years ago, this species has been collected many times. The larvae are often encountered in large numbers, but in the laboratory they are extremely susceptible to disease. Those which pupate frequently do not metamorphose. Only a few adults have been

taken in the field. *Ethmia plagiobothrae* is closely allied to *albitogata*, but the two exhibit marked biological differences.

Study areas. - 1) Cool, El Dorado Co.; larvae abundant on *Plagiobothrys nothofulvus*, April 24, 1961 (C.D. MacNeill and J. Powell) (61D4, 61D5); 1 male, 1 female, March 21, 1962, female retained alive (62C2); investigated for adults, March 29, 1964 and March 23, 1965, negative results. 2) Six miles west of Whiskeytown, Shasta Co.; larvae on *Plagiobothrys* probably *nothofulvus*, May 10, 1961 (R.L. Langston and J. Powell) (61E10). 3) Eight miles south of Leesville, Colusa Co.; larvae on *P. nothofulvus* April 12, 1962 (J.A. Chemsak and J. Powell (62D5); investigated for adults, March 8, 1963, negative. 4) Elk Mountain, 2800-3000 feet, 11-12 miles north of Upper Lake, Lake Co.; 3 females flying in association with, 1 egg, 2 young larvae on *P. nothofulvus*, April 4, 1962 (62D12); investigated for adults, April 9, 1964, negative (penultimate instar larvae on *P. nothofulvus* at 2200 feet, one mile south on the same road); adults sparse, March 18, 1965 (R.L. Langston and J. Powell). 5) Ten miles south of Creston, San Luis Obispo Co.; 3 larvae on *P. nothofulvus*, April 30, 1962. 6) Arroyo Mocho, 18 miles south of Livermore, Alameda Co.; larvae on *P. nothofulvus*, April 30, 1963; investigated for adults, February 23, 1964, March 14, 1965, Feb. 24, 1968, March 4, 1969, Feb. 21, 1970, negative. 7) San Antonio Valley Ranger Station, Santa Clara Co.; mature larvae on *P. nothofulvus*, April 30, 1963; investigated for adults, Feb. 9, 1964, negative; 3 young larvae on *P. nothofulvus*, March 14, 1965; investigated Feb. 24, 1968, negative; 1 male, 1 female, March 4, 1969 (P.A. Opler and J. Powell); larvae common on *P. nothofulvus*, April 27, 1969 (69D58). 8) One mile north of Posey, Tulare Co; larvae common on *P. nothofulvus*, May 14, 1963 (C.A. Toschi and J. Powell) (63E2). 9) Three miles north of Havilah, Kern Co.; 4 larvae on *P. tenellus*, May 15, 1963 (63E10). 10) Fifteen miles southwest of Havilah, Kern Co.; larvae on *P. nothofulvus*, May 15, 1963. 11) Havilah, Kern Co.; larvae common on *P. nothofulvus*, April 28, 1964 (C.A. Toschi and J. Powell) (64D10). 12) One mile east of Woody, Kern Co.; larvae on *Plagiobothrys*, April 25, 1964 (C.A. Toschi), May 3, 1964 (64D16). 13) Three miles northwest of Mariposa, Mariposa Co.; 3 young larvae on *Plagiobothrys*, March 25, 1965.

Adult behavior. - This species has a single annual flight period, in early spring. The few field collections indicate the moths fly in March and early April, ahead of or at about the time the blossom period of the host begins. The development of *Plagiobothrys* is highly variable from one season to another at a given locality, possibly correlated with early spring rainfall, and occurrence of young larvae in mid March, 1965, suggests that the moths are sometimes flying by mid February.

Only one female was observed in captivity (62C2). This field collected individual was caged in a one-gallon

jar with a flat of planted herbs from Cool, and a bouquet of *Phacelia californica* from San Mateo County. The female showed the same activity periods and quiescent posture at night as described above for *E. albitogata*. On one occasion, the female did not move when lights were intermittently on from dusk until 8:00 A.M. In this instance she began activity about 10:30 A.M.

Oviposition behavior, with the abdomen distended and curled towards the leaf substrate, was observed at 12:15, 2:00 and 4:55 P.M. one day, and deposition of eggs was witnessed at 2:30 on another afternoon. On one occasion two eggs were deposited in rapid succession, (a few seconds interval) without apparent probing of the ovipositor, followed by a third egg nearby a few minutes later. A total of 62 eggs was recorded. About two-thirds (44) were deposited on the *Phacelia* (figs. 24-25) and 5 more on grass blades and the glass side of the container adjacent to the *Phacelia*. The remainder were located on what was presumed to be basal rosettes of young *Plagiobothrys*. All but one of the latter group and 90% of those on the *Phacelia* were placed on the undersides of the leaves, which were more hirsute in both cases.

The moth lived nine days after its capture, but probably no oviposition took place after the fourth or fifth day.

Egg. - (Figs. 24-25) The eggs were more variable in shape than most other *Ethmia* studied, ranging in outline from rectangular-oval to ovoid, tapering at both ends; width and length varied accordingly, from 0.22 x 0.47 mm to 0.28 x 0.42 mm.

Development at laboratory temperature required 10-11 days, hatching April 2-4, 11 to 13 days after the female was first caged. Some of the eggs were stored in a refrigerator for 72 hours, and emergence of these was delayed about 3 days beyond the last of the non-refrigerated ones.

Emergence frequently took place off center from the micropyle, by means of an irregular slot contrasted to the more or less evenly oval hole in the middle of the micropylar end, which is usually cut by larvae of other *Ethmia*.

Larva. - Newly hatched larvae were placed on *Phacelia californica*, but none successfully established themselves. A few small spots of skeletonizing represented the only feeding and none of these larvae reached the second instar.

Two young larvae were collected at Elk Mtn., in the basal rosettes of *Plagiobothrys*, but their shelter and feeding were not observed. When preserved, they were in the second and third instar.

Larvae of at least the final two instars fed entirely exposed, on the flowering stalks of *Plagiobothrys*. No visible silk nor other shelter was employed. Larvae could be

found curled around the uppermost flower, feeding on the inflorescences.

Frass was flipped free of the flower parts, appearing on the sides of the container.

In the following larval diagnosis, specimens from Cool and Havilah are mixed in the final two instars. Those from Havilah average smaller, but the ranges of variation are similar.

Evidently this species has five instars (fig. 1), with two well defined color phases in the final instar. It was originally assumed that two instars were involved, but head capsule measurements do not show an appreciable separation. Form (a) has dark gray, almost black integumental markings with yellowish spots in the dorsal band, while (b) has much paler gray integumental bands and conspicuous orange blotches on each segment except the prothoracic. The pale form (b), larvae seemed bulkier and apparently were more mature, but I had no evidence that an ecdysis occurred in development of (a) to (b).

First instar[4]: Length 1.0-1.2 mm; HC 0.20-0.22 mm, pale orange with ocellar area black; integument and setae colorless.

Second instar[1]: Length 3.0 mm; HC 0.36 mm, dark brown; ThSh, Pin small, and setae dark, integument unpigmented; AbdCr 6-7; AnCr 7-8.

Third instar[1]: Length 3.3 mm; HC 0.49 mm, lighter brownish; ThSh not defined; Pin brown, as small as in 2nd instar; integument unpigmented; AbdCr 9-10; AnCr 11.

Fourth instar: Length 6.3-8.8 mm; HC 0.53-0.60 mm, dark brown, poorly defined pale area above labrum; Pin small, dark; DL pale gray, D well defined, LV scarcely pigmented; AbdCr 9-11 (Cool) or 7-8 (Havilah); AnCr 9-11.

Fifth instar: Length, form (a) 10.0-13.0 mm, form (b) 12.9-15.8 mm; HC 0.75-0.85 mm (Havilah, (a) average 0.77, (b) average 0.79 mm), 0.77-0.88 mm (Cool, both forms average 0.83 mm), orange-brown, strongly mottled; ThSh darkened laterally only; Pin black; D white, well defined, each segment except prothoracic with a bright orange blotch as broad as D; DL gray, narrow; L pale with dull, irregular blotch above spiracle; LV pale gray, irregularly mottled; AbdCr 16-20 (usually 17-19), biordinal mesally; AnCr 19-21, biordinal.

Pupa. - Successful pupation occurred in folds of paper toweling or tissue paper, and in yucca pith. Under laboratory conditions most individuals either died as prepupae or young pupae or remained in diapause and did not emerge. On two occasions (61D4, 63E2) single moths emerged early the following year and twice pupae were still healthy appearing

during the second winter: two pupae of 61E10 in December 1962 (19 months after pupating), and one of 64D10 in February 1966 (after 21 months). The latter was placed in an outdoor cage at Berkeley through the spring, 1966, but still did not emerge. Larvae from several lots constructed cocoons in corners of salve tins, and in one case between a cotton plug and glass side of a vial. In all these cases prepupal larvae or pupae became dessicated and collapsed prior to development.

Full grown larvae from San Antonio Valley (69D58) were placed in 35 mm square pill boxes or small salve tins, two or three individuals per container, with a block of yucca cortex in each. After storage at laboratory temperature for 10 weeks they were transferred to the outdoor shed in July. Successful emergence occurred by late February in over 60% of the individuals, suggesting that temperature and moisture rather than photoperiod are stimuli which are important to development during the pupal stage. Cocoons were formed in cracks in the yucca or between the yucca and paper liner.

Pupae from Cool ranged 5.0-5.6 mm in length. The anal legs were dorsoventrally flattened more than in other *Ethmia* studied. In addition they showed a definite tendency for greater lateral expansion distally (appearing boot-shaped in outline rather than evenly expanded laterad and mesad). The free portion was about 0.24-0.27 mm long, with a lateral projection of 0.09 mm. The legs had 32-36 (rarely 38) hooked setae which are about 0.05 mm in length. The setae of the cremaster area were 0.12 mm long and relatively strong, remaining intact during emergence of the moth.

Natural enemies. - About 40% of the groups of larvae in various types of containers became diseased and nearly all larvae in these lots succumbed prior to pupation. Representatives from two affected collections (64D10, 64D16) were submitted to the Division of Invertebrate Pathology at the University of California, Berkeley. G.M. Thomas responded (*in litt.*), indicating that media inoculated directly from titurated specimens produced pure cultures of a *Pseudomonas* sp. and that observations indicated this bacterium was the cause of the disease.

It is assumed that the epidemics were brought on by conditions in rearing, since similarly affected larvae were not commonly seen in the field, and in at least two cases (61D4, 64D10) containers with few larvae did not show the symptoms while those with larger groups did. However, the high incidence of these epidemics and the fact that such symptoms occurred only in this species, *albitogata*, and *charybdis*, indicate that the body flora of these larvae differs from that of most *Ethmia*, causing them to be more subject to disease. This may help account for the fact that larvae of these three species are more easily found in high numerical density in the field than the adults, whereas the reverse is true with other *Ethmia* I have studied.

Ethmia minuta Powell

Ethmia minuta Powell, 1971, U. Calif. Publ. Ent., in press.

This species was collected in southern California as early as 1916, but probably it was not recognized as an *Ethmia* owing to the small size. The elongated, strongly sclerotized ovipositor and smooth egg are features unique to this species among known New World *Ethmia*.

Study areas. - 1) Hills 2 miles northeast of Lakeside, San Diego Co.; adults at midday flying and on flowers of *Cryptantha intermedia*, March 30, 1961 and March 13, 1963. 2) Two miles northeast of Moreno, Riverside Co.; males flying in midafternoon, April 5, 1963 (C.A. Toschi and J. Powell); both sexes flying in association with *Cryptantha intermedia*, April 12, 2:00-4:00 P.M., 4 males, 4 females were retained alive (63D18).

Adult behavior. - *Ethmia minuta* has a single, early spring flight, from mid March to late April. The moths are diurnal. The four pairs from Moreno were caged in an 85 x 100 mm jar with a bouquet of *Cryptantha* April 13-14 under field laboratory conditions. About 20 eggs were deposited during this time, but no observations on behavior were made. On the following day the moths became water soaked during transport from the field in an ice box. Three females partially or fully recovered, and one lived until April 17. It was observed on the *Cryptantha* once, but no oviposition occurred after April 14.

Eggs on April 13 were all deposited between bases of flower buds (figs. 18-20). These were located only in inflorescences with partially developed flowers. Those with larger green seed and no blossoms left were not used for oviposition. Evidently the elongated ovipositor of *E. minuta* is an adaptation for use of the densely bristled inflorescences of *Cryptantha intermedia*.

Egg. - (Figs. 18-20) In contrast to all other species for which eggs were studied, those of *minuta* had a smooth chorion, without visible network of structural ridges under 54x magnification. The shape was roughly oval, circular in cross section, measuring 0.30 x 0.43 mm to 0.25 x 0.47 mm; variation resulted from the situation of placement. Upon dissection of the flowers most eggs were found to be wedged between a sepal and upper portion of a carpel. Emergence of larvae invariably occurred from the inward end of the egg, adjacent to the carpel. Hatching occurred April 22 (± 10 days incubation).

Larvae. - Some of the buds on which the eggs were deposited had dried by the time the larvae began emerging, and they were placed on the exterior of green buds. They seemed unable to crawl on or penetrate the densely bristled vestiture, and several died. None attempted to feed on stems;

no leaves were available.

By opening buds slightly with forceps and inserting two day old larvae, I was able to provide conditions which enabled feeding. Whether the few larvae which successfully established included any of these, or were only those which entered directly from the eggs, was not determined. Feeding by first instar larvae took place at the sides of developing ovules. There was no feeding on petals or sepals, and larvae placed in buds which were too young to have developing ovules did not feed. Most died without establishing successfully, even after some feeding.

Those surviving hollowed out developing ovaries. Second instar larvae were transferred on the fourth day from the drying buds to buds which had been refrigerated two weeks. Again larvae had to be placed into forced open buds and not all succeeded in feeding.

On the twelfth day two third instar larvae were placed on new *Cryptantha* from the refrigerator (originally taken with the moths 21 days earlier). These larvae experienced considerable difficulty and were unable to penetrate the bristled buds after one hour. The two were then placed on flowers which I broke open, but they were still unable to establish easily. After another hour one larva succeeded in beginning feeding on the inner side of the ovary wall. This larva lived until the 17th day after hatching. By this time, however, the 26 day old *Cryptantha* failed to take up water when removed from the refrigerator and no additional foodplant was provided.

First instar: Length 1.0-1.25 mm, HC 0.16-0.17 mm, pale tan, almost colorless, ocellar area black; integument and setae colorless.

Second instar: None preserved; HC 0.27-0.29 mm [2]; integumental markings evident as pale yellow-orange or ochreous-tan blotches surrounding the DL pinacula.

Third instar[2]: Length 3.7-4.2 mm; HC 0.36-0.41 mm, pale to dark brown; DL mottled pale olive-brown; Pin not differentiated, setae and crotchets colorless; AbdCr ±8; AnCr ±8.

Ethmia charybdis Powell

Ethmia charybdis Powell, 1971, U. Calif. Publ. Ent.; in press.

This bizarre species is known from only three localities, having been discovered when we reared a male from larvae collected in 1967. The moth is unique among all *Ethmia* by possession of extremely elongate and peculiarly thin legs, as well as by markedly reduced mouthparts. Primarily on the basis of male genital characters *charybdis* had been placed

as a monobasic species group related to the diurnal group. However, with the discovery, in 1970, of the female which is brachypterous, reevaluation of the species' assignment to *Ethmia* is anticipated.

According to the geographical distributions of the hostplant and of other insects which occur at the type locality, we expected colonies of *charybdis* along the western edge of the San Joaquin Valley and in the Mojave Desert. This has proven to be the case, with collection of larvae in the Mojave in 1970 and recognition of apparently conspecific larvae in the U.S. National Museum collection which had been taken in the southeast corner of San Luis Obispo County[1], in April 1956, "sweeping wheat and various flowers", by G. Beevor of the California State Department of Agriculture. Examination of *Amsinckia tessellata* in a similar habitat to the type locality, at Jocalitos Canyon near Coalinga, Fresno County, in early February and late March proved negative.

Study areas. - 1) Big Panoche Creek, near Fresno-San Benito County line; larvae on *Amsinckia tessellata*, April 20-21, 1967 (J. Powell and P.A. Rude) (67D87); 1 young larva on *Amsinckia*, March, 1968; negative results checking *Amsinckia intermedia* and *A. gloriosa*, March 5, 1969, and *A. tessellata*, April 23, 1969, and with *Amsinckia* not yet germinated, Feb. 5, 1970. 2) Ryan Mountain, Joshua Tree National Monument; larvae on *Amsinckia intermedia*, March 31, 1970 (R.E. Dietz and J. Powell) (70C13).

Adult behavior. - Only two adults, from Ryan Mountain, have been observed alive, serving as indicators of the seasonal and diel activity periods. Emergence occurred at the end of November and beginning of December, after pupal aestivation in closed containers which were housed under laboratory conditions through the summer and in a modified outdoor situation during fall. Field surveys have not been carried out during the fall months, but the normal flight period is presumed to be late fall or winter, in part through comparison with the life cycle of *E. timberlakei*, discussed below, and in part owing to the brachypterous condition of the female in *charybdis*, a characteristic of certain winter moths in other taxa.

As is true in other fall flying *Ethmia*, adults of *charybdis* possess large eyes and nocturnal habits despite the fact that activity, in November in desert habitats, must take place in cold temperatures. Moreover, there was an indication in laboratory *charybdis* that activity is restricted to early morning hours rather than at dusk or early darkness, when it was warmer. No crepuscular movement occurred, and on several evenings activity by one or both individuals did

1 Probably in the vicinity of Cuyama according to M.E. Gardner, Bureau of Entomology, Sacramento, California.

not begin prior to 4-6 hours after nightfall. In every observed nocturnal cycle both moths moved after 11:00 P.M. This behavior may have been artificially induced, because the moths were housed at about 16-18° C during daylight and early evening, and in temperatures declining to about 12-14° C between 11:00 P.M. and 8:00 A.M. It may be that optimal temperatures for *charybdis* are well below 16-18°, and in the field that might occur in early evening. It is not unreasonable to suppose that this species is active at colder temperatures than any other known *Ethmia*. By comparison, the geometrid winter moth, *Operophtera brumata*(L.), in which the female is brachypterous, has been observed to mate and oviposit at temperatures just under 0° C (Cuming, 1961), whereas most other Geometridae, even species which fly only in early spring, are rarely active below a temperature range around 4-5° C, and not at all below 2-3° C according to light attraction records (Powell, 1962).

As in the case of *timberlakei*, *Ethmia charybdis* was able to survive without water. The proboscis is short and may not be functional. No moisture was provided during the first 7-9 days the male was alive or the first 3-4 days following emergence of the female. Whereas a shorter period would have been lethal to most *Ethmia*, there was no evidence of weakening of the *charybdis* adults, and mating took place during this time. Ultimately the male was killed when 10 or 11 days old, while the female, after an oviposition period during which she was provided with water, died 6-7 days after emergence.

Mating occurred during the second or third night following emergence of the female, when the male was 6-8 days old. Copulation was initiated after 11:30 P.M., on an evening when both individuals had been active between 6:30 and 11:30. The pair remained in coition approximately 22-26 hours, showing no signs of activity during this time (even when exposed to electronic flash and direct sunlight for several minutes during photography). Separation occurred, with both male and female moving away, between 4:00 A.M. and 8:00 A.M.

Oviposition behavior was not observed, but it occurred between 12-72 hours after completion of mating and could have begun immediately in the matinal period following mating. Although no protein was provided, the single female deposited 75 eggs, the highest total I recorded for an individual *Ethmia*. The eggs were placed in depressions and holes in yucca pith and under and between layers of tissue paper. The female selected cracks and open beetle galleries in the yucca piece for 11 eggs, which were recessed up to 0.6 mm below the surface. Most of the oviposition (58 eggs) occurred in creases, between layers, and onto the underside of tissue paper liners of the original larval containers and fresh paper provided in the breeding cage. Three eggs were nested adjacent to mouldy frass on the tissue, suggesting that larval evidences on old foodplant may

elicit oviposition stimulus. Dry flower and leaf fragments of *Amsinckia tessellata* from a herbarium sheet were provided but were not selected by the female.

Egg. - The eggs were characteristic of other *Ethmia* in shape and chorion sculpture but were smaller than those of other nocturnal species with forewing length comparable to that of male *charybdis*. Eggs ranged 0.37 x 0.62 mm to 0.30 x 0.67 mm in outline, about the size of those of diurnal species, which the female approximates in body size. Stored at laboratory temperatures, all but a few apparently infertile ones turned yellowish within 3 days, to a peach color by 7-9 days, and later gradually reddish. They showed no signs of maturation by the 15th day, suggesting diapause, but they did not rapidly change to a tomato red color characteristic of eggs in diapause in *Ethmia timberlakei* and in tortricine moths (Powell, 1964). However, color transition in *timberlakei* was not observed and may be a gradual, slower process as in the present species.

Larva. - Younger instars were not observed; individuals thought to be antepenultimate and penultimate were taken by net sweeping. Mature larvae lived exposed on the inflorescences, usually perching on one side, below the highest part of the plant, without any visible webbing. In the laboratory those of the last two instars housed in 32 x 90 mm plastic vials proved to be susceptible to disease epidemics, even though individuals were separated, a few in each container. Others placed in 25 x 75 mm salve tins were less susceptible, and several matured successfully. Shelters were spun among flowers, but these may have been constructed only in preparation for pupation. Feeding probably occurs primarily on developing seed and flower parts under natural conditions.

At maturity larvae spun opaque cocoons in corners of the rearing containers or in foliage (67D87). No soft, woody substrates were provided. The 1970 larvae were offered yucca blocks bearing galleries of cossonid beetles, but the three larvae which successfully completed cocoons all selected folds of tissue paper.

Penultimate instar (?) [2]: Length 9.7-10.0 mm. HC 0.58-0.71 mm; orange, indistinctly mottled with brownish; ThSh brownish, fairly well defined; integument color as in final instar, paler than most but not all individuals; AbdCr 7-10; AnCr 9-15.

Final instar: (Fig. 7) Length 10.0-16.0 mm. HC 0.85-0.97 mm; orange, distinctly mottled with brown; ThSh not well defined, sclerotized areas restricted to posterior margin; integument pale to distinctly colored, D white with a median rust-orange streak (sometimes reduced to a trace), DL fairly uniform dark to pale gray, mottled, defining distinct white circles around pinacula; L white, well defined, with variable elongate blotch of pale to bright rust-orange, LV as in DL,

usually slightly paler; Pin large, black, distinct; AbdCr 15-21; AnCr 21-22. Segment A9 with 0 or 1 very small secondary seta at LV, anal leg with small patch of usually 3 tiny secondary setae.

Pupa. - Pupation occurred in various cocoon situations, but lack of suitable substrates may have ultimately resulted in dessication of several prior to development. The only successful emergences occurred from a cocoon tightly spun in old foliage and flower parts in 1967 and in tight folds of tissue paper in 1970.

Preserved pupae measured 6.0-6.8 mm in length, were smooth, pale orange, without specialized spiracle structures. The anal legs were rather short with slight to no lateral extension distally, with 20-22 anchoring setae. The frail cremaster homologue setae were located on a roughened, but not depressed area.

Ethmia albistrigella (Walsingham)

Psecadia albistrigella Walsingham, 1880, Proc. Zool. Soc. Lond., 1880:89.

Described from the Siskiyou Mountains on the northern border of California, *albistrigella* is widespread in western North America, occupying more boreal regions than the closely related *nadia*, discussed below. Both have small eyes, but according to phenetic assessment are more closely related to members of the semilugens group which are nocturnal, than they are to the foregoing diurnal species (Powell, 1971). It is possible that small eyes and diurnal habits in *albistrigella* are a secondary development as a result of adaptation to high elevations where temperatures early in the season deter night time activity.

Study areas. - 1) Chipmunk Flat, 3 miles west of Sonora Pass, 8800 feet, Tuolumne Co.; adults associated with *Phacelia ramosissima*, June 25, 1962 (C.D. MacNeill and J. Powell) 2 males, 3 females retained alive (62F11); and July 1, 1962, 1 male, 1 female retained alive (62G4). 2) Donner Pass, 7300 feet, Nevada Co.; 1 male, 1 female flying near *P. ramosissima*, July 4, 1962 (C.A. Toschi and J. Powell); larvae on *P. ramosissima*. August 3, 1962 (62H3).

Adult behavior. - *Ethmia albistrigella* has a single annual generation, flying early in the season, in California from mid June to mid July, after the snow in the vicinity has receded to patches and the *Phacelia* has not yet begun to bloom. Adults were apparently actively flying between 1:00 and 3:00 P.M., and I have seen no record of collection of this species at light. In the breeding jar, adults were caged with a bouquet of *Phacelia* from the collection site. They did not show a definite activity period, but laboratory conditions probably differed more (especially warmer in late afternoon, night and early morning) from field conditions with this

boreal species than for any other species studied. Most *albistrigella* moved occasionally or were actively crawling during morning hours, as early as 8:30. Most were active, crawling towards the daylight side of the container, feeding at water, etc. between noon and 5:00 P.M. However, many instances were noted in which moths moved after dark, both with and without lights in the room. They did not seem to be continuously active after dusk, but they were not consistently inactive as in the cases of the diurnal species discussed above.

One mating pair was observed at 8:00 P.M., just prior to sunset, having coupled after 6:30 P.M. Separation occurred in the dark, between 9:15 and 11:00 P.M.

Oviposition was not witnessed, but took place between 1:00 and 2:30 P.M., and at least once between 8:30 P.M. (dusk) and 8:30 A.M., after six days confinement of the female. Eggs were placed only on the *Phacelia* leaves, excepting one or two placed on the glass adjacent to the *Phacelia*. About 70 eggs were deposited by 3 females, almost exclusively on the undersides of the leaves; 2 each were placed on uppersides of leaves and on stems.

Egg. - The shape of eggs was more variable than any other species studied, ranging from oval to kidney shaped or constricted towards one end. The width and length ranged 0.38 x 0.84 to 0.44 x 0.94 mm. Hatching occurred after about 10 days at laboratory temperatures.

Larva. - First instar larvae emerged July 7 and were placed on an immature flowering spike of *Phacelia ramosissima* which had been taken at Chipmunk Flat six days earlier and kept in water. Within two hours, several had begun skeletonizing leaves. Usually the underside of the leaf was selected. Later emerging larvae were placed in plastic vials with leaves and began feeding successfully. By the fourth day successfully established larvae were still in the first instar, located either on the underside or in curled portions on the upperside and had skeletonized several small spots.

After the 9th day larvae were supplied with leaves from a greenhouse *Phacelia ramosissima* transplanted from Chipmunk Flat on June 24. The cut pieces were accepted but turned black after a day or two. A leaf of *Phacelia distans* from San Francisco was supplied to second instar, 11 day larvae, but little attempt was made to feed on it. Thereafter, the greenhouse *P. ramosissima* was used.

By the 16th day all larvae were third instar. Two days later some individuals had reached the fourth instar and were feeding on the full leaf thickness. Generally, very little silk was used in visible shelter preparation.

On the 24th day third and fourth instar larvae were transferred to a branch of *P. ramosissima* in water. All be-

gan feeding without any apparent shelter.

The four surviving larvae reached the fourth and fifth instars by the 28th day, and *Phacelia ramosissima* from Donner Pass was provided.

Some larvae were full grown by the 31st day, appearing blackish with a dull orange-brown dorsal median band. The final larva began its cocoon on the 39th day.

Larvae were observed in the field at Donner Pass 30 days after adults had been collected at this site. By this time the plants had reached full to late bloom in somewhat sheltered, east facing exposure. The larvae, in the third and fourth instars, lived in thin webbing shelters among the inflorescences, usually more or less on the underside of the flowering spike, rather than between the geminate flower rows. The silk was not easily visible, but presence of the larvae was evident by frass, retained by the hairy, viscid texture of *P. ramosissima*. Lower leaves were thoroughly investigated and neither larvae nor signs of larval feeding were found.

Two larvae reached the final instar one day after this field collection, and the first larvae spun cocoons on the 12th day following collection (42 days after adults were observed at the site).

There appeared to be five instars, based on unsexed head capsule measurement (fig. 5). However the size range in later instars suggests a possible sixth instar in occasional individuals.

Second instar: (None preserved) HC [5] 0.36-0.40 mm, pale orange with slightly darker mottling.

Third instar: Length 5.0-9.9 mm; HC 0.55-0.78 mm, orange-brown to dark brown, mottled paler; ThSh pale orange-brown; Pin dark but somewhat diffuse; D whitish, not well defined; DL scarcely evident, ochreous yellow; AbdCr 7-8; AnCr 6-9 (usually 8-9).

Fourth instar: Length 10.4-12.0 mm; HC 0.86-0.96 mm, white anteriorly with dark brown posterior markings; ThSh mottled laterally only; Pindark, small; D unpigmented, not well defined; DL pale ochreous or olive-green with whitish encircling pinacula; AbdCr 9; AnCr 10.

Fifth instar [3]*:* Length 12.2-14.2 mm; HC 1.22-1.32 mm, white anteriorly with black posterior markings; ThSh mottling restricted to small areas at posterior margin; D well defined, unpigmented to dull orange-brown; DL, LV well defined, dark gray to blackish, mottled with unpigmented areas; L well defined, pale, unpigmented or tinged with orange; AbdCr 13-15; AnCr 15-17. Segment A9 with 3 tiny secondary setae just anterior of LV seta.

Pupa. - Full grown larvae were placed in a salve tin with pieces of dry *Phacelia* stems from Donner Pass. The stems were 2-4 mm in width and were hollow or had a soft, pithy context throughout. No larvae used these stems for pupation. Cocoons were spun in the upper and lower corners of the tin. Kept at room temperatures and humidity, the pupae dessicated prior to development. Cocoons were about 12 x 4.5 mm, with a dense, white papery cover and little internal silk mesh.

Pupae ranged 6.8-7.1 mm in length. The anal legs varied in divergence, with one individual having them nearly adjacent. The distal portion had no lateral development and bore about 18 hooked setae. The frail, posterior "cremaster" setae were all short, possibly broken, in the individuals examined. They originated from a depressed, smooth area subtending lateral humps.

Ethmia nadia Clarke

Ethmia nadia Clarke, 1950, J. Wash. Acad. Sci., 40:161.

A difficult taxonomic problem exists concerning relationships of *nadia* and *albistrigella*. The present species occupies generally warmer, drier (Upper Sonoran and Transition Zone) regions than the boreal sites (Canadian and Hudsonian Zone) observed for *albistrigella* in California. In addition, it appears that *nadia* is primarily crepuscular. Possibly it is not obligated to diurnal activity by low night time temperatures as is *albistrigella* at higher elevation stations.

Study areas. - 1) Fowler's Camp, 5 miles east of McCloud, Siskiyou Co.;1 male at Coleman lantern July 7, 1957; 2 males, 1 female, net collected, apparently actively flying in late afternoon and at dusk, July 14, 1962; negative results in examination of *Phacelia mutabilis*, July 21, 1966. 2) Hills back of Citrus Experiment Station, University of California, Riverside, Riverside Co.; larvae on *Phacelia ramosissima* var. *suffrutescens*, May 13, 1962 (62E8). 3) Herbert Creek, 3 miles west of New Almaden, Santa Clara Co.; 1 female net collected between 1:00-2:00 P.M., April 20, 1966 (A.J. Slater and J. Powell); retained alive (66D21).

Adult behavior. - Although the moths have been collected in March and April in southern California and June and July in northern California, it seems likely that a single annual flight is involved. It occurs late in the season compared to other species with small eyes, and is correlated with flight later in the day, at least into a crepuscular phase. In addition to afternoon, dusk, and evening collections listed above, single adults have been taken in the daytime: at Riverside, on flowers of *Cryptantha intermedia* (P.H. Timberlake); at Fairview, Tulare County, at midday, April 27, 1964 (P.A. Rude); and 9 miles south of Fairview,

in late afternoon, April 29, 1964 (P.A. Rude).

A reared female was observed in January 1963, over a 16 day period. No males were available. At laboratory temperatures this individual was active, crawling and feeding at damp cotton, at dusk and each evening with lights on in the room. The moth was not active in morning hours and was not observed to move much during the afternoon. No eggs were laid. When prodded during evening activity periods, the moth would feign death, dropping to the substrate on its back, with the legs tightly clasped to the body. After a few minutes activity was resumed.

The female from Santa Clara County (66D21), caged in April, 1966, was observed only on the first night. It was not active between dusk and 9:30 P.M., or between 5:00 and 5:30 A.M., resting in the quiescent posture. Retained at outdoor temperatures in a 100 x 85 mm jar with a bouquet of *Phacelia distans*, (the only *Phacelia* discovered at the collection site), the moth lived only five days. At least two eggs were deposited between 5:30 P.M. and dusk on the first day and ultimately 24 eggs were laid. Oviposition sites varied in these conditions (crowding and unnatural orientation of the *Phacelia* branch may have been factors). Half the eggs were placed on leaves, both upper and lower surfaces, with the remainder on flower heads (4), stems (2) and the nylon screen over the jar (4).

Egg. - The eggs were nearly cylindrical, measuring 0.40 x 0.80 to 0.38 x 0.85 mm.

The eggs were placed in a refrigerator from April 25 to May 3, and were then stored at room temperature. Hatching occurred after about 17 days (including the 9 days in cold storage).

Larva. - Newly hatched larvae were placed on a cut sprig of *Phacelia tanacetifolia* from the Botanical Garden in a salve tin. Two day old larvae had established mostly on spots under leaves against the salve tin surface. Feeding occurred as skeletonized spots on either upper or lower surfaces of the leaves. However, as the plant material began drying, by the fifth day, all larvae dispersed and escaped owing to a faulty container.

Field collected larvae at Riverside in the final and penultimate instar differed markedly in appearance from *albistrigella*, appearing olive-green with a pale dorsal band. The plants were in full bloom and larvae spun a thin web which enclosed a terminal raceme or a leaflet or two.

Penultimate instar: Length 13.0 mm [1]; HC 0.95-1.07 mm [4]; ThSh not differentiated; Pin minute; no integumental pigment; AbdCr 11-12, uniordinal; AnCr 11.

Final instar: Length 16.5-17.5 mm; HC 1.22-1.28 mm,

orange, strongly mottled with whitish; Pin small, black; D, L fairly well defined, yellowish; DL pale olive-gray, mottled, with whitish encircling pinacula; AbdCr 17-19, biordinal mesally; AnCr 17. Segment A9 with about 12 tiny, unpigmented secondary setae in a row between LV and V setae.

Pupa. - Cocoons were spun in the leaf material and in folds of paper toweling. The outer layer was dense, white, tough, paper-like and could be torn when dry. Inside, cocoons had an ill-defined but strong mesh surrounding the pupa, making it difficult to extract pupal shells intact. Pupae were formed before early August. Successful emergence occurred from nearly all those which had pupated, although they were stored in laboratory conditions. Emergence took place in December and January, well ahead of that of field conditions.

One pupa measured 8.2 mm in length. The anal legs were irregularly to strongly divergent or curved, with a slight lateral development distally. About 30 setae were located in the anchoring group on each leg. The "cremaster" setae were short (possibly broken), in the individuals examined, and were borne in a shallow V-shaped, roughened depression.

Ethmia semilugens (Zeller)

Psecadia semilugens Zeller, 1872, Verh. Zool.-Bot. Ges., Wien, 22:561.

This species is widespread in arid areas from Colorado to Chihuahua and southern California (Powell, 1959, 1971). Although there had been only a single record for California, we were fortunate in discovering larvae on two species of *Phacelia* at one locality at the northern end of the Panamint Valley in 1969.

Study area. - Darwin Wash, 1-3 miles west of Panamint Springs, Inyo Co.; larvae on *Phacelia calthifolia*, May 12, 1969 (P.A. Opler) (69E65); larvae on *P. calthifolia* and *P. crenulata*, May 14, 1969 (J. Powell and P.A. Rude) (69E78, E79).

Adult behavior. - Collection records indicate this species is facultatively double-brooded, with flight records for late February and March to September, but mostly in April and July. Records in California are for April and May, and individuals we reared either emerged in July or went into a prolonged diapause. The moths are nocturnal, judging from eye size and light attraction records. Adults were not observed in the laboratory.

Egg. - Unknown.

Larva. - Individuals of at least four instars were found on annual plants along a rocky roadside and wash bottom, a

site which had been heavily eroded during the preceding winter. The caterpillars lived externally on the undersides of leaves and stems without any visible webbing. Feeding evidently occurred entirely on leaves, although both host species were in bloom at the time. In the laboratory, larvae were housed in polyethylene bags or plastic freezer dishes and continued to feed more or less exposed. Foliage of the two plants became mouldy easily. However, larvae did not seem to be susceptible to disease outbreak and provided with refrigerated leaf material, larvae matured 7-14 days following collection.

Cocoons were formed in folds of paper toweling. No soft woody substrate was offered. Mature larvae took on a pinkish cast while wandering in search of pupation sites.

Head capsule measurements did not clearly define instars, and there may be six instars in this species. The following diagnosis represents a somewhat arbitrary instar division, based in part on crotchet numbers and secondary setae.

Second instar (?): [4] Length 3.5-6.0 mm; HC 0.32-0.48 mm, unicolorous dark brown; integument unpigmented, body appearing more or less uniform pale green; ThSh brown, nearly unicolorous to blotched; Pin dark, conspicuous, but relatively smaller than in later instars; AbdCr 9-13, uniordinal, essentially a complete circle; AnCr 7-8.

Antepenultimate instar: Length 7.0-10.5 mm; HC 0.56-0.75 mm, color of HC, ThSh, and integument as in preceding instar; AbdCr 8-15 (usually 10-13), partially biordinal; AnCr 8-12.

Penultimate instar: Length 12.0-14.5 mm; HC 0.85-0.98 mm, whitish mottled with extensive blackish areas; integument color as in preceding instars, except D yellow, DL darker greenish, L with a yellow blotch on each segment; Pin darker, larger; AbdCr 13-16; AnCr 10-12.

Final instar: Length 15.5-23.0 mm; HC 1.07-1.36 mm, white with black markings posteriorly; ThSh unpigmented except two lateroposterior, variable black patches; D bright yellow, DL bright green with unpigmented areas around pinacula; L whitish with large yellow blotch on each segment; LV greenish; Pin large, black; AbdCr 15-28 (usually 20-24), biordinal; AnCr 20-24, biordinal; segment A9 with 3-6 small secondary setae between LV and V setal groups.

Pupa. - Cocoons spun in folds of paper toweling were flat, oval, with an opaque, white cover; pupation occurred within 10 days of cocoon construction. All pupae apparently entered diapause. A few emerged in early July, after 6-7 weeks at laboratory conditions. The remainder did not metamorphose; exposure to outdoor shed conditions through the following year failed to stimulate completion of development

and emergence. Some appeared to remain viable after 16 months.

Pupae (figs. 8-9) ranged 8.6-9.1 mm in length and were unusually dorso-ventrally flattened. Each spiracle was followed posteriorly by a raised area which was subtended ventrally by about 50 tiny spicules. The anal legs were moderately to strongly diverging, well separated at the base, distally without any enlargement. Each had 15-16 hooked setae. Caudally 4 "cremaster" setae were borne on each of 2 raised areas corresponding to the anal prolegs of the larva, and these setae were stronger than on other *Ethmia* examined, yet still non-functional.

Ethmia arctostaphylella (Walsingham)

Psecadia arctostaphylella Walsingham, 1880, Proc. Zool. Soc. Lond., 1880:88.

Speculation that the name *arctostaphylella* is a misnomer and that *Eriodictyon* is the host of this species (Powell, 1959) has proven to be correct. *Ethmia arctostaphylella* has been found closely associated with *Eriodictyon* in various parts of California on many occasions, while no evidence that *Arctostaphylos* is a foodplant has been forthcoming. Adults fly in late afternoon and at dusk around *Eriodictyon* plants, and they can be found resting on the leaves or flushed from foliage during mid day. They have been taken on *E. californicum* at many stations in northern California, on *E. trichocolyx* var. *lanatum* in San Diego County, on *E. crassifolium* in the Santa Rosa Mountain foothills of Riverside County, and on *E. tomentosum* in San Luis Obispo and San Benito Counties. The study areas cited below are only those in which early stages have been involved, among the many records for the moth's occurrence on *Eriodictyon*.

Study areas. - 1) Carson Ridge near Woodacre, Marin Co.; 1 female, 2 larvae, on *Eriodictyon californicum* May 14, 1960 (60E1). 2) Hills north of Alpine Lake, Marin Co.; larvae on *E. californicum*, May 28, 1960 (J.M. Burns and J. Powell) (60E6); adults on *E. californicum*, April 17, 1961 (C.D. MacNeill and J. Powell), 5 males, 7 females retained alive (61 D3). 3) Three miles west of Stoneyford, Colusa Co.; young larvae on *E. californicum*, May 11, 1961 (61E13). 4) Ten miles east of Clearlake Oaks, Lake Co.; 1 mature larva on *E. californicum*, May 11, 1961 (61E14). 5) Two miles east of Groveland, Tuolumne Co.; 1 larva on *E. californicum*, June 12, 1961. 6) Mt. Diablo, 3000 feet, Contra Costa Co.; 2 larvae on *E. californicum*, July 17, 1961 (61G2). 7) Eight miles north of Boulder Creek, Santa Cruz Co.; 1 male, 1 female, 1 cocoon on *E. californicum*, Aug. 11, 1962 (62H6). 8) Five miles east of Boulder Creek, Santa Cruz Co.; adults, cocoons, larvae on *E. californicum*, Aug. 11, 1962 (62H7).

Adult behavior. - In the foothills of central California the moths fly as early as February, commonly in April and in all subsequent months until September. Adults and larvae occur together during summer, suggesting overlapping generations. At higher elevation sites spring emergence occurs in May, and only two generations may obtain.

In the field the moths become active before sundown and fly into the night, according to light attraction records. In the laboratory activity began by 6:00 P.M., prior to sunset, and was highest during the next two hours. Some individuals remained active as late as 11:00 P.M., but they moved more slowly and activity generally appeared to diminish late at night, although temperature change was not occurring.

When at rest during the daytime, both in captivity and in the field, the moths assume the characterisitic quiescent posture and often perch on the upperside of the elongate *Eriodictyon* leaves, oriented with the body axis along the mid vein. The white and grey color pattern causes the moths in this position to resemble bird droppings.

Mating pairs were observed four times. One pair was swept from *Eriodictyon californicum* at Mt. Tamalpais, Marin County, between 4:00 and 4:30 P.M. on a cool, windy day in mid March, 1964, by C.W. O'Brien. In the laboratory one pair was first seen at 8:30 P.M.; the couple moved at least once, but remained stationary from 9:45 to 11:30 P.M. Separation occurred between 11:30 P.M. and 7:30 A.M. The second pair apparently mated between 8:00 and 9:30 P.M. and remained in coition until after 10:30 P.M. The other copulation occurred five days after the adults were caged, when the moths had become very worn appearing. The pair was observed at 7:30 A.M., having mated sometime after 6:30 P.M.

Oviposition occurred at various times of night. One female was observed probing the nylon screen ceiling with the ovipositor at 6:00 P.M. Many eggs were deposited between 6:00 and 7:30 P.M. and between 7:30 and 10:30 P.M., and a few were deposited after 11:30 P.M.

About 200 eggs were produced by 7 females. More than 60% of these were placed on the *Eriodictyon*; 27% were deposited on the nylon screen. Of those on the plant 90% were on leaves, but there was no significant difference in preference for higher or lower leaves on the stem. Even a lower leaf which was black with sooty mould (as the lower leaves of *E. californicum* always are in the field) had 15 eggs. About two thirds of those on leaves were placed on the upperside, and all but 8 (of 80) on the uppersides were deposited along the mid vein (figs. 26-28).

In captivity, males lived 4 to 7 days, females 4 to 8 days, but water was not provided after the fifth day.

Egg. - (Figs. 26-28) The eggs were elongate, and slightly flattened (slightly wider than thick), measuring about 0.40 x 0.83 to 0.44 x 0.90 mm.

During development the eggs turned pink by the third day. Hatching occurred after 9 to 10 days at laboratory temperatures. Eggs of the fall generation were not observed, and the overwintering stage or stages are unknown.

The eggs proved to be impervious to water. Several deposited in a field collection vial were submerged when the vial was used as a water source in the breeding jar. After five days the vial was allowed to dry. These eggs all hatched on the 11th to 13th day after their deposition.

Larva. - First instar larvae were placed in salve tins with immature terminals of *Eriodictyon californicum*. Larvae tied two leaflets together or spun silk between a leaflet and the container. Feeding occurred as skeletonizing. By the sixth day most individuals were still in the first instar. Six and eight day old larvae were placed on *E. californicum* in water vials. The plant kept well in this condition and bloomed, but larvae did not establish well. Apparently they wander considerably even though fresh leaves are available. Leaves in salve tins did not keep well and larvae had to be transferred every few days.

By the 26th day larvae were in the third instar. Feeding at this stage occurred as skeletonizing on older leaves. Larvae constructed small silken trackways between leaves.

Some larvae had reached the fourth instar by the 32nd day. No attempt was made to rear these further owing to difficulties in keeping the plant, which resulted in frequent exposure of the larvae to mouldy leaves.

Larvae collected in the field were of various stages from about half grown to mature. Most of these were not preserved. Larger larvae typically constructed shelters by spinning silk across the upperside of one leaf, pulling its margins towards the center. In new foliage the leaf margins were often drawn completely together, forming a tubular shelter, open at both ends. On older leaves which had hardened, the margins were drawn in only partially, forming a hammock shaped shelter with a silken mat ceiling, under which the larva rested, oriented along the midrib. The amount of visible silk varied, possibly with age of occupancy, and sometimes only a thin layer of silk covered the larva which was visible from above. Even so, and despite the fact that the larvae are brightly marked with red and black, their general light green color rendered them inconspicuous under the silk. In searching, the silk was usually seen first, and probably the larvae are thus protected from visual detection by larger predators.

On one occasion (61E13) several larvae were feeding in

inflorescences and immature terminal leaves of *E. californicum*. None of these shelters resembled the characteristic single leaf type observed at other localities. Two or three young leaves, or sepals and flower parts were tied with silk. As in other situations, many abandoned shelters were present. In the laboratory these larvae seemed to prefer leaves, which were consumed before the flowers. *Eriodictyon* blooms only in spring; flower parts and developing seed are not available to summer feeding larvae.

Final instar larvae of *E. arctostaphylella* ranged from strongly marked, with black longitudinal bands and orange dorsal spotting, to virtually unpigmented, pale greenish with tiny dark pinacula. Some of the latter appeared to be full grown, and I had no evidence that any individual developed from one color phase to the other.

First instar: Length 1.8-2.0 mm; HC 0.27-0.30 mm, orange-brown, ocellar area black; ThSh pale brown; setae and integument unpigmented.

Second instar: None preserved.

Third instar: Length 6.8 mm [1]; HC 0.62-0.71 mm [2] brown; ThSh defined laterally only; D defined, pale; DL indistinct, dark gray; Pin small, not surrounded by pale areas; AbdCr 6-7; AnCr 8-9.

Fourth instar: Length 10.4 mm [1]; HC 0.84-0.89 mm (parasitized) [3], 0.87-1.0 mm [5], dark orange-brown with regular, posterior darkened areas laterad and mesad on each epicranial lobe; ThSh defined, mottled dark; Pin large, dark; D defined, unpigmented; DL distinct, dark to pale gray, Pin not defined by pale; L and LV not distinguished, pale and grayish mottled; AbdCr 9-12; AnCr 9-12.

Fifth instar: Length 14.3-19.4 mm [3]; HC 1.29-1.35 mm (starved) [3], 1.40-1.60 mm, orange-brown lateral and mesal markings not as well defined as in fourth instar; ThSh unpigmented except tiny black pinacula; integumental pigment lacking to well developed, when developed, D well defined, pale orange or orange-brown; DL black, well defined with little pale mottling; L well defined; LV pale, indistinct; AbdCr 15-16 to 19-20; AnCr 19-21. Segment A9 with about 8 secondary setae on LV.

One larva from Mt. Tamalpais (unnumbered collection) exceeds above limits, representing a possible 6th instar. Length 18.4 mm; HC 1.73 mm; AbdCr 21, strongly biordinal; AnCr 23, biordinal.

Pupa. - Pupation in captivity occurred in folds of paper toweling and in shelters in foliage similar to those occupied by larger larvae. Whether these were shelters previously used for feeding was not ascertained. The general behavioral tendency to wander and burrow into soft substrates, known

for many other *Ethmia*, does not seem to be consistently practiced by *E. arctostaphylella*. This is the only New World species which has been recorded as using foliage for pupation. Walsingham reared the original specimen from a cocoon in foliage of *Arctostaphylos*, suggesting the larvae wander. In field searches I discovered cocoons of this species on the *Eriodictyon* at two localities in August, 1962. Five cocoons with viable pupae were located in tightly folded leaves, these resembling the typical larval shelters except more closely closed over the occupant. The dense, opaque, white outer layer of silk, covered a thin, loose silken envelope, which was evident at the ends of the leaf fold.

One adult was reared from a dry flowering stalk of *Yucca whipplei*, collected near Cajon Pass, San Bernardino County, in December, 1962. The cocoon was located at the end of a tunnel several cm in length into the woody cortex, according to the collector, Eric Jessen.

Development by non-diapausing pupae required 11-13 days, including cocoon formation (60E6).

Cocoons measured about 14 mm in length and were tough with dense internal mesh. Pupae ranged 8.5-9.5 mm in length. The anal legs were broad with slight lateral enlargement, each distally bearing 27-30 hooked setae which were about 0.14 mm in length. The caudal "cremaster" setae were borne in a shallow, flattened trough; all were short, probably broken in the individuals observed.

Natural enemies. - Braconid wasps of the genera *Apanteles* and *Microgaster* were reared from larvae of *arctostaphylella* at four scattered localities. *Apanteles* (n. sp. #141 of W.R.M. Mason): Alpine Lake (60E6, 3 of the 7 larvae not preserved). *Microgaster* (n. sp. #22 of W.R.M. Mason): Stoneyford (61E3, 1 of 6 larvae); Mt. Diablo (61G2, 2 of 2 larvae); Groveland (unnumbered collection, 1 larva).

The three parasitized larvae at Alpine Lake were still living when discovered, although each already had a braconid cocoon alongside it. The mothe larvae crawled slowly if prodded, but there appeared to be no recent feeding in the shelters. One of the three was retained alive, and it lived three days after collection. In each case the braconid larva had emerged from a hole in the side of the third abdominal segment just below the spiracle of the host.

Ethmia discostrigella (Chambers)

Anesychia discostrigella Chambers, 1877, Bull. Geol. Surv. Territories, 3:122.

This is the most commonly collected species of *Ethmia* in the New World. The adults are nocturnal and sometimes are

attracted to lights in great numbers. Despite its abundance over a wide range in western North America, until recently nothing was known of its life history (Powell, 1959). *E. discostrigella* and the closely related *semitenebrella* have diverged from the typical pattern of the genus and feed on species of *Cercocarpus* (Rosaceae). In Great Basin regions of eastern California, typical *discostrigella* is associated with *Cercocarpus ledifolius*. In cismontane parts of the state, where the moths are generally more bluish white in appearance and the name *subcaerulea* Walsingham is applicable, *C. montanus* (=*betuloides*) is the principle host. For purposes of the present discussion the two are treated together.

The moths have been flushed from foliage of *Cercocarpus* at a number of sites: from *C. minutiflorus* at San Diego, from *C. montanus* in the mountains of San Diego County, Kern County, and Lake County, from *C. alnifolia* on Santa Cruz Island, and from *C. ledifolius* in the Warner Mountains, Modoc County. The study areas listed below are those which have involved the early stages. In addition, M.M. Furniss of the U.S. Forest Service sent me a large series of larvae and reared adults from *Cercocarpus ledifolius* collected in Owyee County, Idaho.

Study areas. - 1) Crooked Creek, 10,150 feet, White Mountains, Mono Co.; young larvae on *Cercocarpus ledifolius*, July 4, 1961 (61G1); 2 females at light, July 22, 1961, retained alive (61G4). 2) Lee Vining Campground, Mono Co.; young larvae on *C. ledifolius*, July 19, 1961 (61G3). 3) Lake Pillsbury, Lake Co.; 1 female at light, April 3, 1962, retained alive (62D1). 4) miles east of Monitor Pass, Mono Co.; adults at light, June 30, 1962, 2 males, 4 females retained alive (62G3).

Adult behavior. - Collection records from a station in Monterey County, where a continuous sample of insects attracted to light was made throughout a season, indicated that three or more overlapping generations obtain (Powell, 1959). In Great Basin areas probably a single flight, in June and July, is normal. Under laboratory conditions pupae resulting from eggs laid in June and July in Mono County did not emerge the same season but underwent diapause, emerging the following spring.

Although the moths are easily startled into flight during the daytime, both in the field and laboratory, even in early morning, normal activity is nocturnal. Caged females became active at dusk and engaged in oviposition behavior then. Whether or not lights were directly on them seemed not to affect behavior of females except they tended to congregate in the portion of the jar towards the light. The moths are active all night under favorable temperature conditions, judging from light attraction records.

Mating was not seen in the laboratory, and field observations suggest that it may occur only late at night. One

pair was taken from a congregation of scores of individuals on a vertical sheet before a 15 watt blacklight, between 12:30-2:00 A.M., east of Monitor Pass, June 25, 1962. Numerous mating pairs were observed in tree foliage at Fandango Pass, Modoc County, in May, 1970, between 9:00-11:00 A.M. by P.A. Rude.

During oviposition females continuously walked slowly with the abdomen curled downward and prodded the substrate with the ovipositor. Females sometimes did this on the plants provided (*Cercocarpus ledifolius* for Mono County, *C. montanus* for Lake County moths), but more often used the nylon screen ceiling. In one case (62D1) nearly all 28 eggs were placed on the jar rim under the screen. In the 62G3 lot, four females deposited a total of 82 eggs; only 14 of these were on the *Cercocarpus*, 8 of those on the silk of an abandoned caterpillar shelter. Propensity for selection of other fibrous and roughened substrates was shown. About 30% of the eggs were placed on top of the rim of the jar, between the rim and the appressed nylon ceiling; another 25% were located on masking tape on the floor of the container (but only 4 eggs were placed on the smoother cardboard which was of greater area). Three were placed on a patch of cotton fibers which had stuck to the vial holding the plant. Of those on the *Cercocarpus* two eggs were placed on terminal stems, adjoining leaf bracts, etc., but none were laid on the larger, woody stems.

These oviposition sites suggest the possibility of use of the elongate, twisted, soft-hairy style of the fruit, which are persistent on the trees, for egg placement in the field.

Adults did not survive well in captivity, the Lake County female living 7-8 days, those from Mono County even fewer.

Egg. - The eggs were somewhat irregular in outline, evidently conforming somewhat to the substrate. Those from one 61G4 female were oval, flattened, tapering in outline toward one or both ends and measured 0.70 x 1.27 to 0.72 x 1.40 mm.

White when first deposited, the eggs turn bright pink on the second day, remaining so until just prior to hatching when the dark larval head capsule becomes visible and the eggshell looks whitish, semiopaque.

Hatching occurred in 9 days in July, in 10 days in April at laboratory temperatures.

Larva. - First instar larvae (62G3) were placed on *Cercocarpus ledifolius* from Monitor Pass, which had been in water 10 days. Nine days later some had reached the second instar. Larvae at this stage were inconspicuous, living in crotches of twigs and subsessile leaves, with little visible silk. Feeding occurred as small round skeletonized spots,

mostly on undersides and on apical half of leaves. Young larvae were easily disturbed and quickly dropped down on silken threads at the slightest stimulus.

Cercocarpus ledifolius from the collection site was provided at 9, 19, and 35 days, after refrigeration, and seemed to take up water and serve adequately as larval food.

By the 16th day larvae had reached the third instar. By this time, and thereafter, the larvae were extremely reactive to external stimuli - prodding caused them to wriggle backwards extremely quickly, so as to appear to jump, often going 10 to 20 cm on a flat surface.

At 20 days most individuals were in the fourth instar, and all larvae had reached the penultimate instar by the 25th day.

By the 35th day all larvae had reached the last instar. As in the case of *E. plagiobothrae*, two distinct color phases were shown: a paler one showing bluish dorsolateral bands and a lighter orange dorsal band, and a dark form, which was more common, with the dorsal band yellow-orange to rust-orange, the dorsolateral bands black.

The final full grown larvae, in the pale state, were preserved on the 41st day.

Larvae collected as second instar at Crooked Creek required a longer period to mature, probably owing to poorer food conditions. These larvae were provided with cut twigs of *C. ledifolius* in salve tins. After 13 days fresh *C. montanus* from Contra Costa County was provided. All subsequent feeding took place on this plant. Intermittently the plant material dried, leaves frozen for 14 days were provided, and fresh *C. montanus* was provided again on the 36th day.

The first cocoon was formed 48 days after collection of second instar larvae, and the last larva died after the 58th day when additional foodplant from the freezer was added.

There appear to be five instars (fig. 6). The rather wide spread in head capsule measurements in the final two instars may have been caused by differential laboratory conditions, since field collected larvae were taken in young instars.

First instar (62D1): Length 2.3-3.0 mm; HC 0.31-0.30 mm, pale tan, slight brownish spots; Pin visible on thorax. (61G4): Length 3.1-3.3 mm; HC 0.34-0.38 mm, pale tan with brown dorsolateral and venterolateral spots; ThSh brownish laterally; Pin brownish, diminishing on posterior half of abdomen. (62G3): Length 2.7-3.1 (one day) to 4.2 mm (9 days); HC 0.36-0.39 mm, pale tan becoming darker at 9 days; Pin pale brownish, becoming darker and well defined on whole abdomen.

Later instars are characterized on the basis of 61G1 and 62G3 specimens.

Second instar: Length 4.7 (Teneral) - 6.0 mm; HC 0.50-0.55 mm, dark brown without appreciable mottling; Pin dark brown, those of ThSh larger; integument otherwise without pigment, setae dark; AbdCr 6; AnCr 8.

Third instar: Length 6.7-8.0 mm; HC 0.60-0.91 mm, yellow-tan with faint brownish mottling and dark and frontal spots; Pin dark, large; D well defined, pale orange; DL heavily mottled, gray to blackish with a paler (less densely mottled) median streak; L not well defined, LV with almost no pigment; AbdCr 10-11 (rarely 12); AnCr 11-13.

Fourth instar: Length 9.1-15.1 mm; HC 0.96-1.24 mm, yellowish with black adfrontal spots; Pin dark; D well defined, orange with blackish spots; DL well defined, blackish, darker than 3rd instar, obscuring pinacula; L well defined, pale; LV almost as dark as DL, Pin only slightly darker; AbdCr 13-17; AnCr 18-22, biordinal.

Fifth instar: Length 15.9-21.5 mm; HC 1.46-1.68 mm, orange, mottled darker orange along posterior margins; Pin dark, relatively smaller than preceding instars; D well defined, dark orange (dark phase) or yellow-orange (pale phase); DL pale gray or blackish, less densely mottled than 4th instar, densest at D and L margins; L pale, not well defined; LV mottled gray, pale to dark, not well defined; AbdCr 23-30 (usually 28-30), biordinal mesally; AnCr 26-30, biordinal. Segments A1, A2, A9 with 1-3 small secondary setae on LV.

Pupa. - Cocoons were constructed in the corners of salve tins, incorporating a few plant parts. One individual used a rolled leaf. Pupation occurred within ten days after starting construction of the cocoon. Those pupating in mid and late August went into diapause and were housed in the dark salve tins at laboratory temperatures overwinter. Emergence occurred in late April and early May, probably about a month ahead of the flight period in Mono County.

Pupae ranged 7.7-8.7 mm in length (61G3). The anal legs protruded ventrally more strongly than in most other species and were relatively smaller, widely spaced, and strongly diverging, sometimes extending almost directly ventrad and laterad. There were 17-18 (rarely 12) hooked setae on each anal leg. The caudal "cremaster" setae were extremely long and frail, up to 1.4 mm long (twice as long as the hooked setae of the anal legs), borne on weakly to well developed lateral humps. Usually they were broken off in the cocoon.

Ethmia semitenebrella Dyar

Ethmia semitenebrella Dyar, 1902, Jour. N. Y. Ent. Soc., 10:204.

As discussed elsewhere (Powell, 1959) this and the preceding species, *discostrigella* are closely related. Subsequent studies have shown that the two share similar biologies, using species of *Cercocarpus* as hosts. In the original description Dyar mentioned that *E. semitenebrella* was reared from *C. parviflorus* in Arizona.

Study area. - Four miles east of Monitor Pass, Mono Co.; adults at light, June 24 and 30, 1962, 2 males, 6 females retained alive on latter date (62G2).

Adult behavior. - This species is geographically and ecologically restricted compared to *discostrigella*, and *semitenebrella* appears to have only a single annual flight.

The moths are nocturnal. Adults were caged after 36 hours storage in a field ice box. They became active at dusk and showed a similar activity pattern to *discostrigella* from the same locality. Neither oviposition nor mating was observed. Females behaved similarly to those of *discostrigella* in prodding the ovipositor through the nylon screen. All the *semitenebrella* died 5-6 days after collection.

Only 44 eggs were deposited by the 6 females. As in the case of *discostrigella*, a preference for roughened surfaces was shown, but 30 of the 44 were deposited on the floor of the jar, possibly in part a function of age or weakening of the females. All but 3 of these were laid on masking tape or in a crease in the cardboard. Only 3 eggs were deposited on the *Cercocarpus*. Seven eggs were placed on the nylon screen, but none were at the rim of the jar adjacent to or under the appressed nylon, a site used for 30% of *discostrigella* eggs.

Egg. - As in *discostrigella*, eggs of the present species were not regularly rectangulate or ovate, but varied to some extent with the substrate, often tapering towards one end. Those deposited on the nylon screen measured 0.66 x 1.40 to 0.70 x 1.32 mm.

All turned uniform dull reddish prior to the fifth day, darkening only shortly before eclosion. Eggs began hatching July 13, about 10.5-11 days after oviposition. Most were transported on a field trip July 13-15; and those remaining unhatched survived transit in an uncooled car at 40° C air temperature, conditions which were lethal to young larvae, hatching between 8:00 and 11:00 A.M. the following day, about 11 days incubation.

Larva. - First instar larvae were placed on terminals of *Cercocarpus ledifolius* which had been in refrigeration 12

days. Those emerging prior to July 15 did not survive automobile transport in 40° C air temperature. The remaining first instars hatched July 16 and were placed on 15 day old refrigerated *C. ledifolius*. They showed a marked tendency for positive phototropism during daylight hours, crawling to the top of a vial, away from leaves or to the side of a branch toward the light.

Larvae established in small webs in crotches of leaves and twigs or between leaves. Larvae had reached the second instar before the 14th day. Additional *C. ledifolius* from Monitor Pass was provided on the 14th day, after 30 days in refrigeration.

The third instar was reached on the 15th to 16th day, and the fourth by the 20th day. Although the original branch had become covered with fine mold by 10-14 days, larvae had not left it and were transferred to the fresher foliage which had been added to the bouquet 6 days previously. At this time evidence of larvae had become quite noticeable, with considerable webbing which at times collected frass on the uppersides of leaves.

The final instar was reached by the 29th day and the last full grown larva was preserved on the 35th day. To the unaided eye mature larvae appeared steel blue-gray with bright yellow dorsal and lateral bands. The venter was bright pink, differing from *discostrigella* which had a pale venter.

Too few specimens were preserved to enable precise determination of the number of instars.

First instar: Length 3.3-3.5 mm; HC 0.45-0.47 mm, pale tan with black ocellar area, becoming entirely dark brown at maturity. No integumental pigment.

Second instar: Length 8.2 mm [1]; HC 0.64-0.66 mm [5], pale brown, mottled darker; Pin brown, rather large; integument otherwise unpigmented, setae black; AbdCr 8-11; AnCr 11.

Penultimate instar (none preserved): Length 9-10 mm; HC 1.04-1.28 mm [2], pale orange, shaded brownish, not strongly mottled; D yellowish; DL pale bluish.

Final instar [3]: Length 15.9-23.0 mm; HC 1.70-1.87 mm, orange, mottled with white laterally; Pin dark brown, scarcely differentiated from integumental dark areas, strongly contrasting in pale areas; D and L distinct yellow; DL dark steel gray to blue-gray, irregularly mottled with small white spots; LV only lightly mottled; V bright pink, a subintegumental color; AbdCr 28-30 or 32-34; AnCr 30-34. Segment A9 with 12-14 small secondary setae on a sclerotized patch extending 1/2 the distance to V seta.

Ethmia timberlakei Powell

Ethmia timberlakei Powell, 1971, U. Calif. Publ. Ent.; in press.

This species is closely related to *geranella* Barnes and Busck, and may prove to represent a segregate of that species when more is known of both. These and related species differ from most other *Ethmia* in life cycle, feeding as larvae in spring, aestivating as pupae, and flying in fall. The biology of *E. macelhosiella* Busck, a member of the group in eastern United States, was studied by Busck and Heinrich (1922).

Study area. - Hill back of Citrus Experiment Station, University of California, Riverside; larvae on *Phacelia ramosissima* var. *suffrutescens*, March 21 and 24, 1961 (P.H. Timberlake, R.L. Langston and J. Powell) (61C12, C13); larvae on *P. ramosissima*, May 13, 1962 (62E7).

Adult Behavior. - Only a single individual has been field collected, at light between 8:30 and 10:00 P.M. on October 17, 1960, near Desert Springs, San Bernardino County. Closely related species have been taken at lights between mid September (8000 feet elevation) and November (1000 feet). Adults of *E. timberlakei* emerged prior to November 8 (61C12) and between November 1 and 19 (62E7).

Reared moths were observed in late November, 1962. One male and two females already in worn condition were caged in a dry jar with debris and cocoons from the original rearing container. The moths were inactive during daylight and appeared reluctant to move at night with lights on in the room. At this time they moved only by short, quick "jumps" when disturbed by the observer. They were active at night with the lights off.

Fertile eggs were deposited prior to November 19, but not after that date. Although no water was available, the moths lived 11-14 days after first observed, when already in worn condition.

Numerous eggs were deposited, primarily in aggregated groups, not in any systematic arrangement, around the glass side of the jar near the upper rim. A few scattered eggs were laid on the dry *Phacelia* foliage and paper toweling. Most had turned reddish by November 19 and apparently entered diapause.

Although kept in a dry container at laboratory temperatures, about half of the eggs hatched at sporadic intervals during the following spring.

Larva. - In late March, 1961, larvae of at least the final three instars were present on *Phacelia ramosissima*. Most were in the last instar. In mid May, 1962, only full

grown larvae were present, and evidences of feeding indicated that most had already left the plants.

Larvae of *E. timberlakei* differed in habits from most other species studied (including *nadia* at the same site) by living exposed on the leaves, without any shelter. During the daytime most were concentrated towards the lower portions of the dense foodplant clumps, rather than exposed in direct sunlight. In several cases the bushes grew adjacent to large boulders on a southerly exposure. The caterpillars rested toward the back of the clump, in the shade, where the foliage was most dense. Almost all perched on the undersides of stems or main midrib of the compound leaves.

Presence of larvae was evidenced by scattered frass toward the distal end of the branch, evidently held by the viscid hairiness of the plant. Probably larvae moved outward at night to feed, and rested under the stems inactively during the day.

A few small webs were found on undersides of leaves, with associated head capsules. It is assumed these were moulting webs, but it may be that early instars, which were not observed, construct weak shelters.

In rearing, larvae were housed in 85 x 100 mm jars in field conditions for 7 to 10 days and severe moisture condensation and moulding of foodplant resulted. However, no disease symptoms developed. Fresh *Phacelia*, presumed to be *ramosissima*, from San Diego County, was provided on the 5th day, but little or no feeding occurred on it.

Most of the larvae successfully formed cocoons by the 12th day after collection.

Second instar (?) [2]: Length 6.0 mm; HC 0.47 mm, entirely dark brown; Pin tiny, dark; almost no other integumental color; D, L weakly white, Abder 8-10; AnCr 7.

Third instar (?): Length 6.0-7.8 mm (teneral), 9.5-11.0 mm; HC 0.61-0.68 mm (teneral and parasitized), 0.73-0.83 mm, dark brown with pale mottling anteriorly; D defined, whitish; DL pale gray; Pin black, small; integument otherwise unpigmented; AbdCr 8-11; AnCr 7-11 (usually 10-11).

Penultimate instar: Length 10.4-12.0 mm; HC 0.87-0.97 mm, dark brown posteriorly, whitish anteriorly; D well defined, yellowish; DL mottled grayish (appearing bluish green in life); L distinct, yellowish; Pin dark, small; AbdCr 14-16; AnCr 15-16.

Final instar: Length 9.5 mm (unfed?), 15.6-17.2 mm; HC 1.0-1.23 mm, white, mottled with brownish black posteriorly; ThSh defined by small blackish mottling; Pin small, black; D yellow; almost no other integumental color, DL pale grayish, lightly mottled (appearing pale bluish green in life), leav-

ing irregular unpigmented areas around pinacula; AbdCr 14-20 (usually 17-20); AnCr 16-21.

Pupa. - Cocoon formation occurred mainly in folds of paper toweling in the rearing container; a few were formed in mouldy foliage. Pupae were formed soon after cocoon construction. At least one pupa was present by April 5, 12 days after the larvae were collected.

In the field no cocoons were located on the foliage, even in late season condition, in May, 1962. The closely related *E. macelhosiella* was reported to burrow into bark of trees and logs for pupation (Busck and Heinrich, 1922). At Riverside, the dry chaparral association contains no plants with large woody trunks and appreciable thickness of bark. The pithy, dry stems of previous years' *Phacelia* growth was the only likely site evident in which larvae might burrow, but search of a large random sample of preceding years' stems revealed no abandoned cocoons.

The cocoons were about 11-12 mm long and exteriorly were papyrus-like in consistency, not translucent and could be torn like paper. Inside there was little loose mesh, and pupal shells could be easily extracted without breakage.

Pupae measured 7.5-8.2 mm in length. The cremaster setae were observed intact on several individuals, about 0.11 mm in length, very frail, curving towards the tip. The anal legs were widely spaced (0.33 mm apart at base), not diverging, and short, the free part only about 0.23 mm in length. The distal end bore 18-20 anchor setae in several examples.

Cocoons were stored in dry jars at room temperature and successful emergence occurred from nearly all, during a three week period in late October and the beginning of November.

Natural enemies. - The colony at Riverside was affected by a braconid, an undescribed species of *Microgaster* (n. sp. #8 of W.R.M. Mason). In the laboratory *Ethmia* larvae reached the final instar prior to emergence of the braconid larvae. Numerous wasps were reared, and it is assumed that each affected the host solitarily. However, no estimate of the proportion of the sample which was parasitized was made. Under laboratory conditions *Microgaster* adults emerged in May, apparently out of phase with any available stage of the ethmiid.

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Explanation of Figures

Figs. 1-6, larval head capsule measurements in six species of *Ethmia*. Each square represents one individual. Diagonal-lined squares represent larvae reared from eggs in lab; solid, half-solid, and shaded squares represent field collected larvae. Rearing lot numbers refer to data given in text. Size scale (mm) is the same in figures 1-5.

1. *E. plagiobothrae* Powell
2. *E. albitogata* Walsingham
3. *E. b. brevistriga* Clarke
4. *E. scylla* Powell
5. *E. a. albistrigella* (Walsingham); dotted line indicates hypothetical size of first instar.
6. *E. discostrigella* (Chambers)


62C2
69D58
64D10
61D4
mm
0.5
1.0
1
68B178
63E1
2
61D2
61E21
3
69C90
69D60
4
62F11
62H3
mm
0.5
1.0
5
62G3
61G3
61G1
mm
0.5
1.0
1.5
6

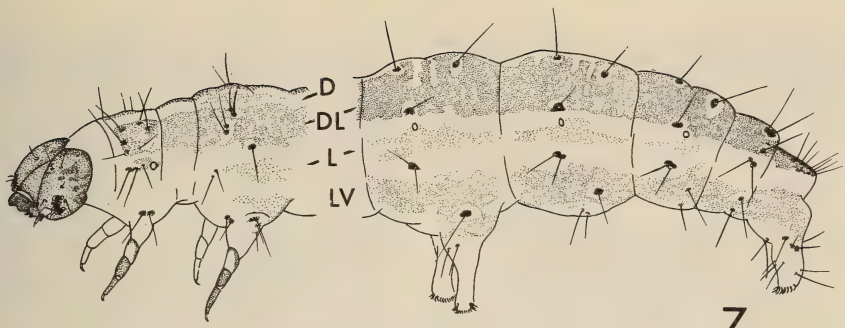
Explanation of Figures

Fig. 7, final instar larva of *Ethmia charybdis* Powell; head and thoracic segments I-II, dorsolateral aspect; abdominal segments 6-10, lateral aspect. Body regions: D = dorsal, DL = dorsolateral, L = lateral, LV = lateroventral.

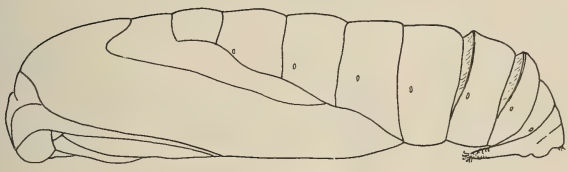
Figs. 8, 9, pupa of *E. semilugens* (Zeller); 8, ventral aspect; 9, lateral aspect.

Fig. 10, pupa of *E. scylla* Powell, ventral aspect.

Figs. 11, 12, egg of *E. coquillettella* Busck, illustrating placement on nylon mesh, a substrate commonly selected by females of various species under cage conditions; 11, ventral aspect; 12, lateral aspect. Length of egg = approximately 0.80 mm.



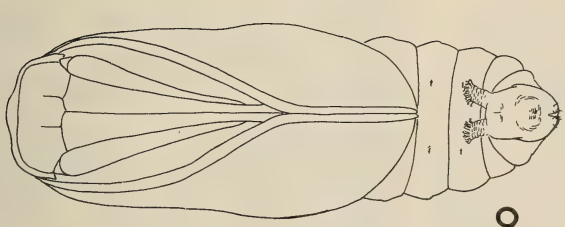
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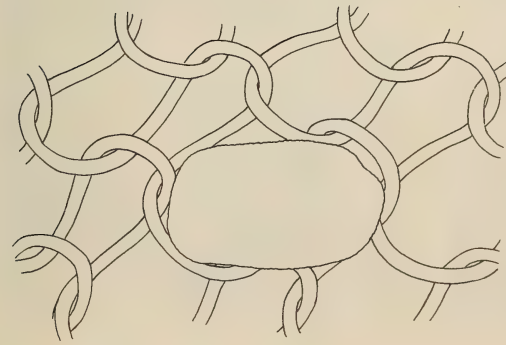
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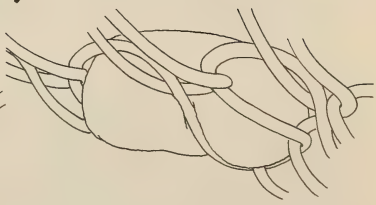
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11



12

Explanation of Figures

Figs. 13-20, eggs of *Ethmia* (approximate magnification indicated in parentheses).

13, 14, eggs of *E. scylla* Powell (69C90) in petiole axils of *Collinsia heterophylla* (4x).

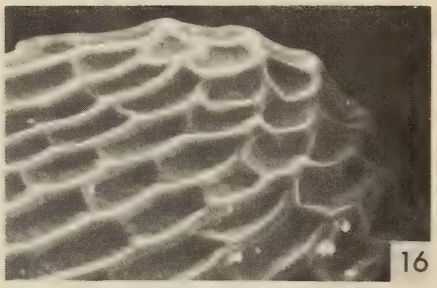
15-17, scanning electron micrographs of *E. scylla* eggs and detail of chorion structure (69C90); 15, (60x); 16, (300x); 17, (1200x).

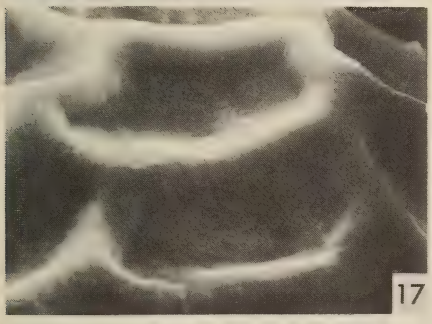
18-20, eggs of *E. minuta* Powell (63D18) in unopened, hispid inflorescences of *Cryptantha intermedia*; 18, (12.5x); 19, (7x); 20, (7x).


13

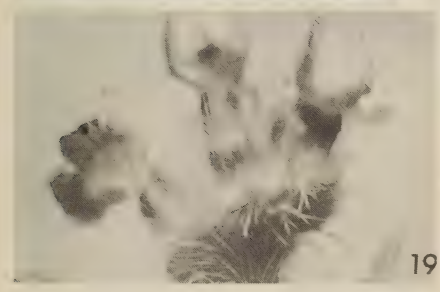

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Explanation of Figures

Figs. 21-24, eggs of *Ethmia* on natural plant substrates (approximate magnification indicated in parentheses).

21-23, eggs of *E. b. brevistriga* Clarke (61D2); 21 on sand-encrusted lower branch of *Phacelia distans* (7x); 22, on underside of mid-vein of *P. distans* compound leaf (7x); 23, same eggs (12.5x).

24, eggs of *E. plagiobothrae* Powell (62C2) on underside of *Phacelia californica* leaf, an abnormal host which was partially accepted by females but not accepted by larvae (7.5x).



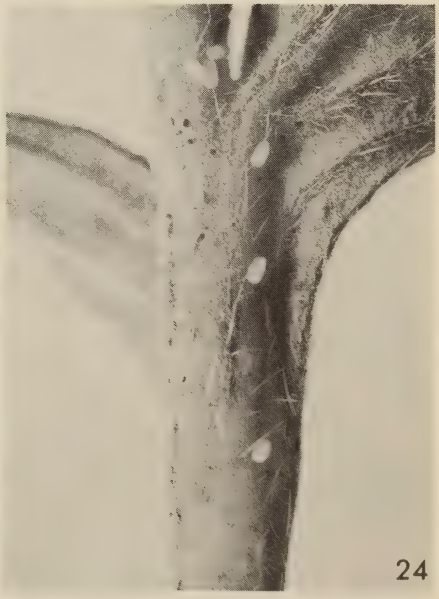
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23



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Explanation of Figures

Figs. 25-29, eggs of *Ethmia* on natural plant substrates (approximate magnification indicated in parentheses).

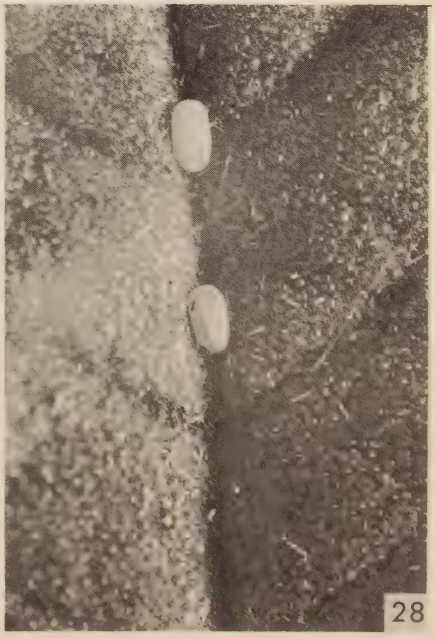
25, eggs of *E. plagiobothrae* Powell (62C2) on setose stem of *Phacelia californica*, an abnormal host (13.5x).

26-28, eggs of *E. arctostaphylella* (Walsingham) (61D3) on *Eriodictyon californicum*; 26, on lower branch encrusted with sooty-mold (7.5x) (the lower foliage commonly becomes covered with sooty-mold owing to glandular secretions of this plant); 27, on mid-vein, upperside of leaf (7.5x); 28, same eggs (12x).


25


26


27


28

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2. Records, new species, and a new genus of Hesperiidae from Mexico; by H. A. Freeman; 62 pp.

3. On the frequency of butterflies in eastern Brazil, with a list of the butterfly fauna of Pocos de Caldas, Minas Gerais; by Hans Ebert; 48 pp.

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